NON-CALCAREOUS MICROPLANKTON FROM THE CENOMANIAN OF ENGLAND, NORTHERN FRANCE AND NORTH AMERICA
PART I

BY

ROGER JACK DAVEY

Pp. 103–180; 11 *Plates*; 16 *Text-figures*

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CONTENTS

SYNOPSIS

This paper, which will appear in two parts, presents the results of a detailed study of some non-calcareous microplankton from the Upper Cretaceous, and in particular of assemblages of Cenomanian age. The stratigraphical potentialities of the fossil microplankton are briefly assessed by the analysis of samples from five localities in England and one in France. To assess the potentialities of long-range correlation, assemblages from Saskatchewan and Texas have also been examined. Both quantitative and qualitative methods have been employed and the correlations, both intra- and inter-regional, are promising. Seven new genera and thirty-five new species and varieties are described.

I. INTRODUCTION

Fossil non-calcareous microplankton consist mainly of cysts of dinoflagellates, together with various forms of unknown affinity placed in the Group Acritarcha Evitt (1963). The majority of dinoflagellates are free-living, oceanic and planktonic. They have a complex life-cycle, usually composed of four stages, in one of which (the motile stage) they are capable of limited vertical movement by the use of two flagella. During the life cycle, if the organism is subject to adverse conditions, a resting cyst is formed. This, most palynologists believe, is the only stage

in the dinoflagellate life-cycle preserved in the fossil state. Fossil non-calcareous microplankton are useful as stratigraphic indices because they are planktonic, of relatively resistant composition, abundant in most marine sedimentary samples, and easy to extract. Hence the principal object of the study was to assess how accurate dinoflagellate cysts are for intra- and inter-regional stratigraphic correlations.

The order of description of the dinoflagellate cyst-families follows that in Sarjeant

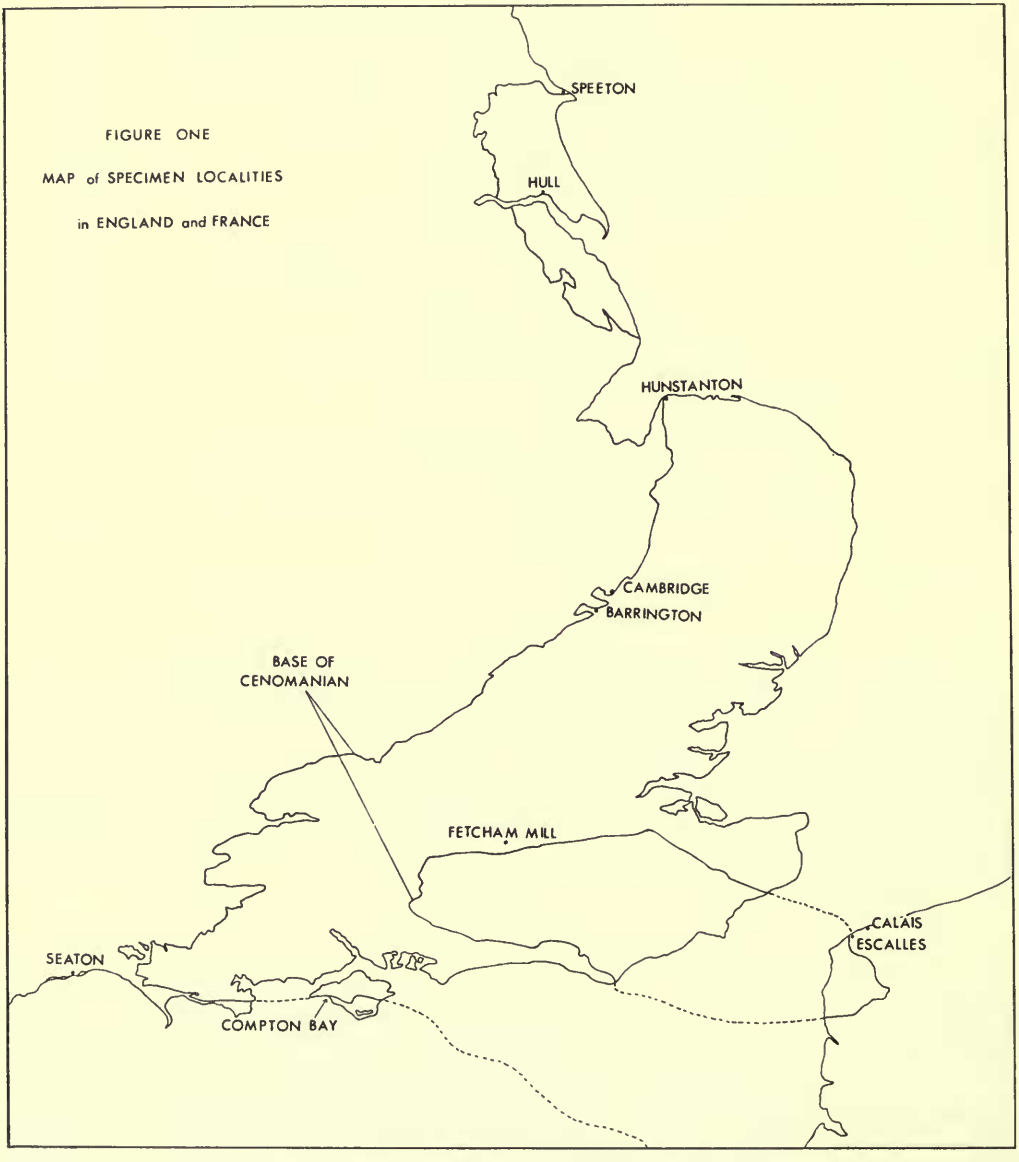

FIG. 1. Map of specimen Localities in England and France.

& Downie (1966). The adjectives used when describing the frequency of a species in an assemblage have been defined as follows:—

Very Common	10–100%
Common	1–10%
Infrequent	0·1–1%
Rare	0·01–0·1%
Very Rare	under 0·01%

The first fossil microplankton were described and figured by Ehrenberg (1838, 1843, 1854) and included forms embedded in flakes of Upper Cretaceous flint from Germany and Denmark. These observations stimulated English microscopists in the mid-nineteenth century into finding these organisms in English flints of the same age.

Little further research in this sphere was published until 1933 when O. Wetzel described assemblages from Upper Chalk flints of the Baltic region. In 1934 Deflandre published the first of a number of well illustrated papers dealing with fossil microplankton from the flints of the Paris Basin. Unfortunately the stratigraphic horizons of the flints are unknown, many being picked up in the streets of Paris. His two most important papers describing Upper Cretaceous microplankton were published in 1936 and 1937. They contain accurate figures and descriptions of many new species and genera mainly from the Senonian, although some of the flints are probably of Cenomanian and Turonian age.

Between 1936 and 1952 few papers dealing with microplankton from the Upper Cretaceous were published. Firtion (1952) described the first definite Cenomanian assemblage, the material having been obtained from the Lower Cenomanian of France. All his species have subsequently been observed in the Lower Chalk of England and France except for *Pareodina* sp. which is unidentifiable. Firtion's *Hystrichosphaeridium* cf. *salpingophorum* may correspond to *H. mantelli*, and *Micrhystridium ambiguum* is probably *Cleistosphaeridium huguonioti*.

Since 1955 a number of publications have been produced dealing mainly with the systematics of Cretaceous microplankton. Assemblages have been described from Germany by Gocht (1957, 1959), Eisenack (1958), and Alberti (1959, 1961), but only the latter author records Cenomanian species. Alberti (1961) described a series of assemblages from the Valanginian to Turonian of northern Germany. Eight species were recorded from the Cenomanian and all of these, except for *Korojonia dubiosa*, have been found during the present study. *Hystrichodinium pulchrum*, identified by Alberti from the Cenomanian, is here included within *Hystrichodinium voigti*. *Gonyaulax orthoceras*, figured by Alberti, is undoubtedly *Cribroperidinium intricatum* sp. nov., and *Palaeohystrichophora* cf. *paucisetosa* is probably a form of *P. infusorioides* possessing fewer spines than usual.

Lower Cretaceous assemblages were described by Neale & Sarjeant (1962), Pocock (1962), and Tasch, McClure & Oftedahl (1964). Górka (1963) described nine species of microplankton from the Cenomanian of Poland. All of these species have been found in the Cenomanian deposits of England and France, although some are considered to be incorrectly identified. *Gonyaulax orthoceras*, illustrated by Górka

appears to be *Gonyaulacysta exilicristata* sp. nov. and her *Gonyaulax* sp. is probably *Cribroperidinium intricatum*; *Hystrichosphaeridium asterigerum* is probably equivalent to *Oligosphaeridium complex* and *Hystrichosphaeridium polytrichum* possibly to *Cleistosphaeridium armatum*. Her *Hystrichosphaeridium* cf. *striolatum* may also belong to the latter species.

Balteș (1963) described eight species of microplankton from the Cenomanian deposits of Roumania. Of these seven have been recorded in the present study. The species not recorded, *Ascodinium hialinium*, probably belongs to the genus *Deflandrea*. The identities of three other species are in doubt: some of the specimens illustrated as *Hystrichosphaeridium longifurcatum* probably belong to this species (transferred to *Surculosphaeridium* by Davey *et al.* 1966), but one specimen (pl. 7, fig. 12) probably belongs in *Hystrichosphaera*. *Histrichosphaeridium* sp. 22 resembles *Exochosphaeridium striolatum* var. *truncatum* nov. and *Hystrichosphaeridium* sp. 23 is possibly *Cleistosphaeridium multifurcatum*.

Manum & Cookson (1964) describe species of supposed lower Upper Cretaceous age from Arctic Canada and of these, eight have also been recorded from the Lower Chalk of England and France; however, the Arctic Canadian assemblages are more comparable to those obtained from Saskatchewan.

Cookson & Hughes (1964) gave the first account of microplankton from the deposits of Upper Albian and basal Cenomanian age in England. Thirty-three species were described from the Cenomanian and of these only six have not been recorded from the basal Cenomanian of Fetcham Mill (sample FM 840) and Compton Bay (CB 1).

A number of papers have been published (between 1954 and 1965) dealing with the microplankton of Australia and, in part, of New Guinea and Papua—Deflandre & Cookson (1954, 1955), Cookson (1956, 1965), Cookson & Eisenack (1958, 1960*a*, *b*, 1961, 1962*a*, *b*) Eisenack & Cookson (1960), and Cookson & Manum (1964). Unfortunately it is usually only possible to give the approximate age of the samples and, therefore, stratigraphic conclusions are not as meaningful as one would have hoped.

A number of species from the Cenomanian deposits of England were described by Davey, Downie, Sarjeant & Williams (1966) and the present paper published in two parts forms a natural continuation of that work.

Clarke & Verdier (1967) describe microplankton assemblages of Cenomanian to Senonian age from the Isle of Wight, southern England. The Cenomanian samples examined by them were obtained from a locality approximately sixteen miles to the east of Compton Bay. Their results indicated that the Upper Cretaceous could be divided into 5 zones and 5 subzones, and also into 7 " intervals " based on extinction points. The results concerning the Cenomanian are mainly substantiated in the present study.

ACKNOWLEDGMENTS

The research has been carried out during the tenure of a research studentship in the Department of Geology, The University of Nottingham.

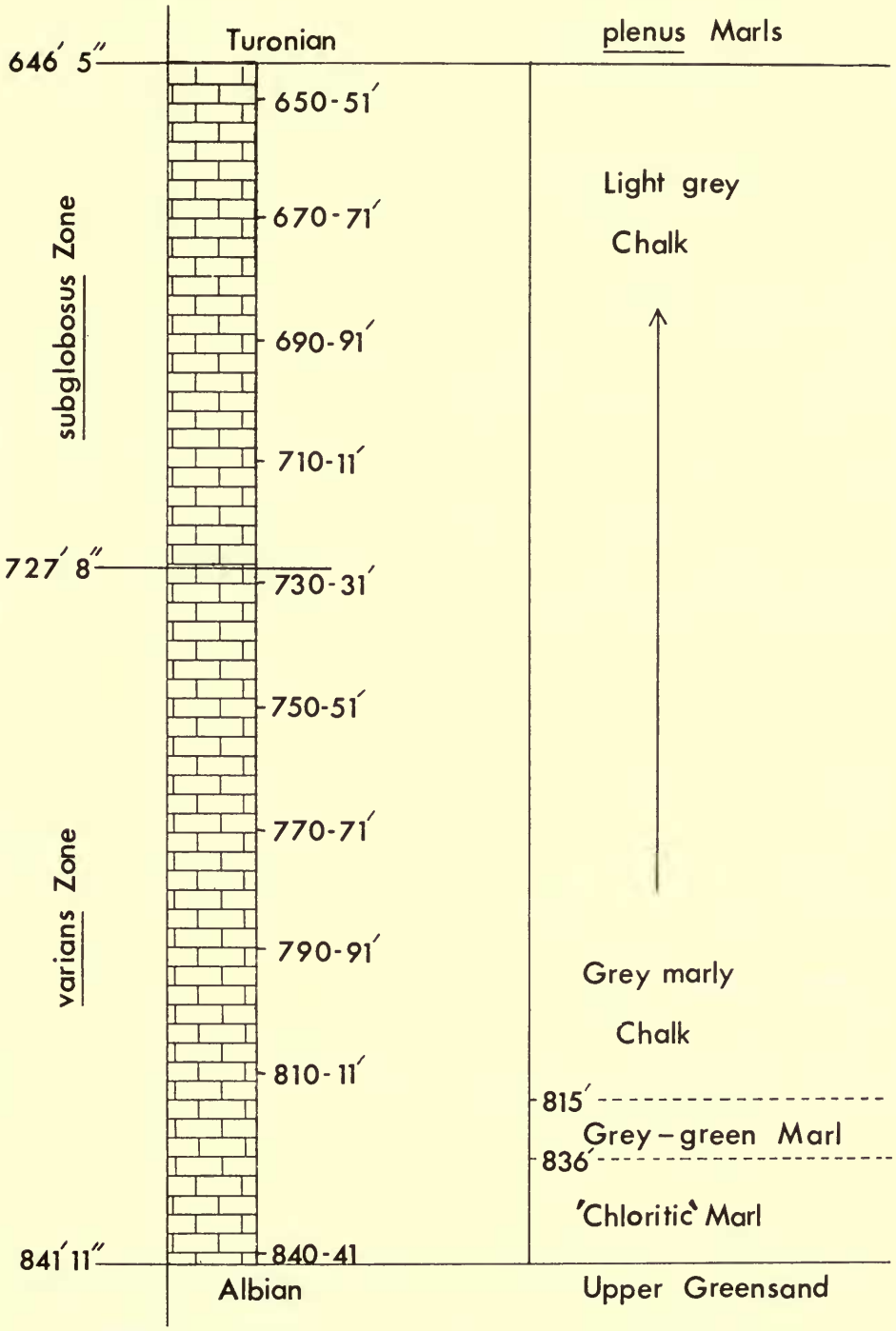

FIG. 2. Section showing the Location of the Samples analysed from Fetcham Mill, Surrey. Scale 1 inch to 30 feet.

The author would like to thank sincerely Dr. W. A. S. Sarjeant for considerable help and encouragement given at all stages during the course of this work, and also particularly acknowledges the interest and encouragement given by Professor W. D. Evans and Dr. A. J. Rowell. Thanks are due to Professor G. Deflandre for courtesy in entertaining the author and allowing him to examine type material at the Laboratoire de Micropaléontologie, École Practique des Hautes Études, Paris; and to Dr. G. L. Williams for his collaboration when dealing with the systematics of certain genera. The author is indebted to Mr. R. Hendry and his staff in the Department of Geology, The University of Nottingham for their assistance and provision of necessary laboratory equipment.

Special thanks are due to Sir James Stubblefield, former Director of the Institute of Geological Sciences, for permitting study of chalk samples from the Fetcham Mill Borehole; to the Bureau de Recherches Géologiques et Minières, for providing chalk samples from the Escalles Borehole; to the Department of Mineral Resources, Saskatchewan, for providing Cretaceous samples from the International Yarbo Borehole no. 17; to Dr. J. D. Powell, for providing Upper Cretaceous samples from Texas; to Dr. W. E. Smith, for providing samples from the Cenomanian of south Devon; and to Dr. K. Diebel, of the Institut für Paläeontologie, Humboldt University, East Berlin, for courteously permitting the loan of Ehrenberg's holotypes.

The following abbreviations are used in the text: B.M. (N.H.)—British Museum (Natural History): G.S.M.—Institute of Geological Sciences, London.

II. STRATIGRAPHIC LOCATION OF SAMPLES

1. **Fetcham Mill Borehole,** Leatherhead, Surrey (TQ 15815650).

This borehole has been described by Gray (1965). Ten samples at 20-foot intervals were processed from the Cenomanian (Lower Chalk) succession (Fig. 2). In addition one sample from the Albian (Upper Greensand) and one from the Turonian (Middle Chalk) were analysed for comparative purposes.

2. **Compton Bay**, Isle of Wight (SZ 365854)

The Cenomanian is well exposed in the cliff section at this locality and has been described by Jukes Browne (1903) and Osborne White (1921). Samples were collected at 7–8 ft. intervals and eleven samples, at approximately 14 ft. intervals, were analysed for their organic-shelled microplankton content (Fig. 3).

3. **Speeton,** Yorkshire (TA/166750)

The Cenomanian succession is fully exposed in the cliffs at Speeton. The base of this stage was taken to coincide with the bottom of bed V (Wright 1963) which, together with the overlying bed U, is placed in the Red Chalk (Fig. 4). The succession has been described recently by Kaye (1964). Seven samples were collected and analysed for their microplankton content.

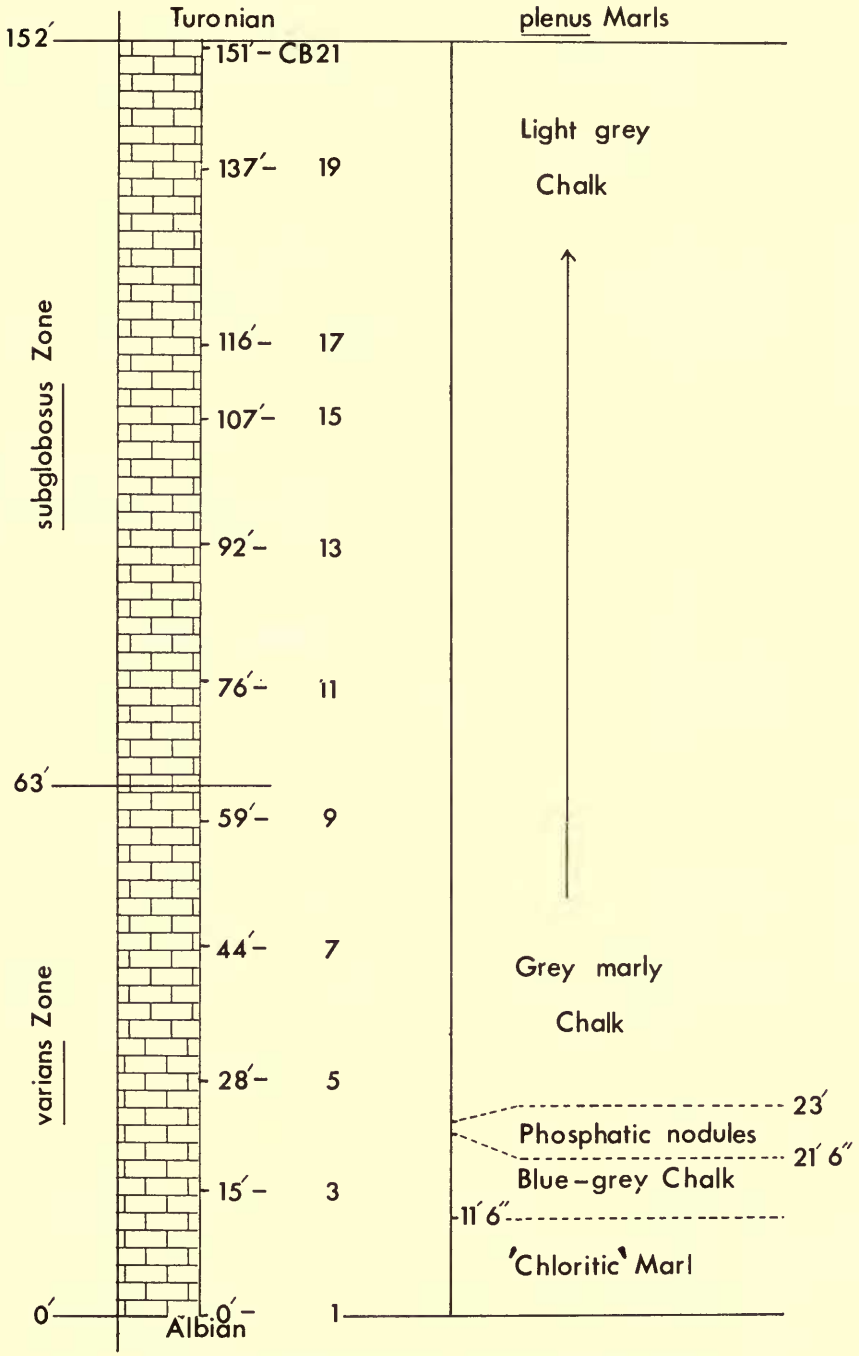

FIG. 3. Section showing the Location of the Samples analysed from Compton Bay, Isle of Wight. Scale 1 inch to 20 feet.

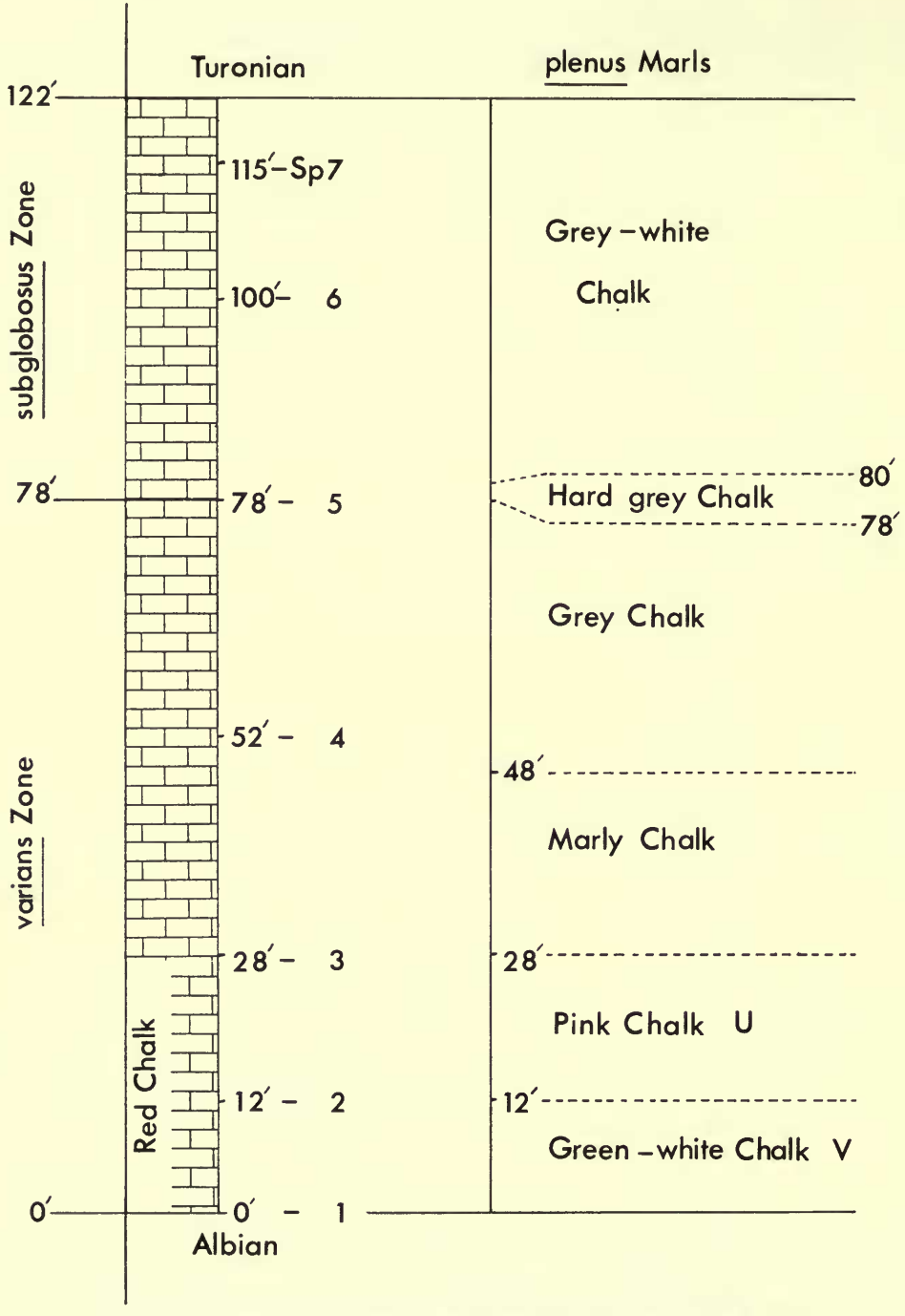

FIG. 4. Section showing the Location of the Samples analysed from Speeton, Yorkshire. Scale 1 inch to 20 feet.

4. **Hunstanton,** Norfolk. (TF 675420)

The *varians* and *subglobosus* zones are exposed in the Hunstanton cliffs (Peake & Hancock 1961). Three samples were processed, two from the lower zone and one from the base of the Totternhoe Stone (Fig. 5).

5. **Devon,** South Coast

The Cenomanian is represented between Salcombe and Lyme Regis by isolated patches composed of a few feet of sandy Cenomanian Limestone. These deposits were divided into four beds by Jukes-Browne (1903)—A1, A2, B and C. Bed C is probably the *Actinocamax plenus* Marls. The samples were collected from four localities by Dr. W. E. Smith (Fig. 6):

(i) *Maynards Cliff* (see Smith 1961 : 114)
(ii) *Beer Head* (see Smith 1957 : 123)
(iii) *Whitecliff* (see Smith 1957 : 118)
(iv) *Humble Point* (see Smith 1965 : 126)

6. **Escalles Borehole,** Cap Blanc-Nez, Pas de Calais

The borehole, drilled by the Bureau de Recherches Géologiques et Minières in 1958 has been described by Destombes (1961). Eleven samples were obtained for analysis at about 20 ft. (6m.) intervals (Fig. 7).

7. **Saskatchewan,** south-east

The borehole, from which the Saskatchewan samples were obtained, was drilled for the Department of Mineral Resources, Saskatchewan and is called " International Yarbo, no. 17 ". It is located east of Regina at Lsd. 1, Sec. 24, Twp. 20, Rg. 33, W1st Meridian. All depths are measured from the Kelly Bushing which is at an elevation of 1,690 ft. above sea level. Six samples of Albian/Cenomanian age were analysed for their microplankton content (Fig. 8).

8. **Texas,** north

Two samples were obtained from the Upper Cenomanian of north Texas (Tarrant County) for the author by Dr. J. D. Powell. The lower sample (T5) was obtained from the Upper Woodbine Formation (*Acanthoceras wintoni* Zone) and consists of a yellowish, slightly calcareous clay. The higher sample (T4) is from 35 ft. above the base of the Eagle Ford Formation (*Eucalycoceras* Zone). This is a thin-bedded yellow limestone containing shelly fossils and plant debris, in particular leaf fragments.

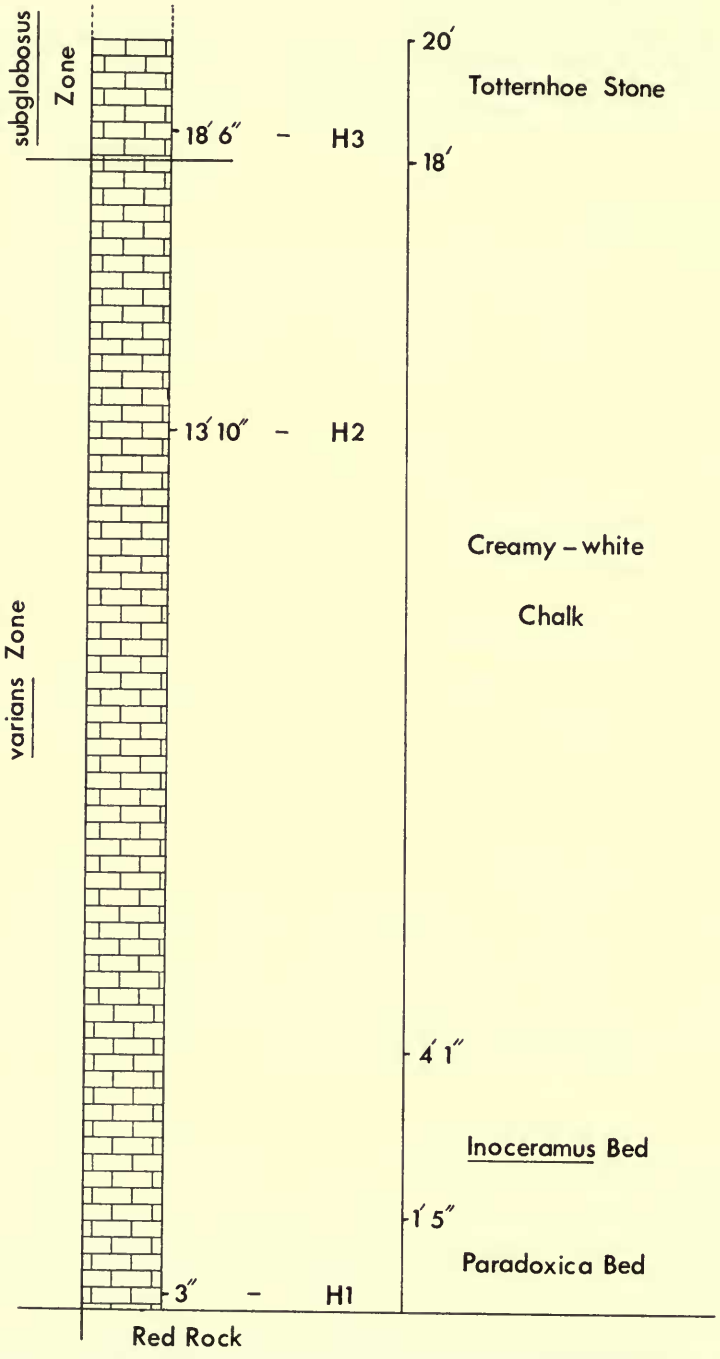

FIG. 5. Section showing the Location of the Samples analysed from Hunstanton, Norfolk. Scale 1 inch to 2½ feet.

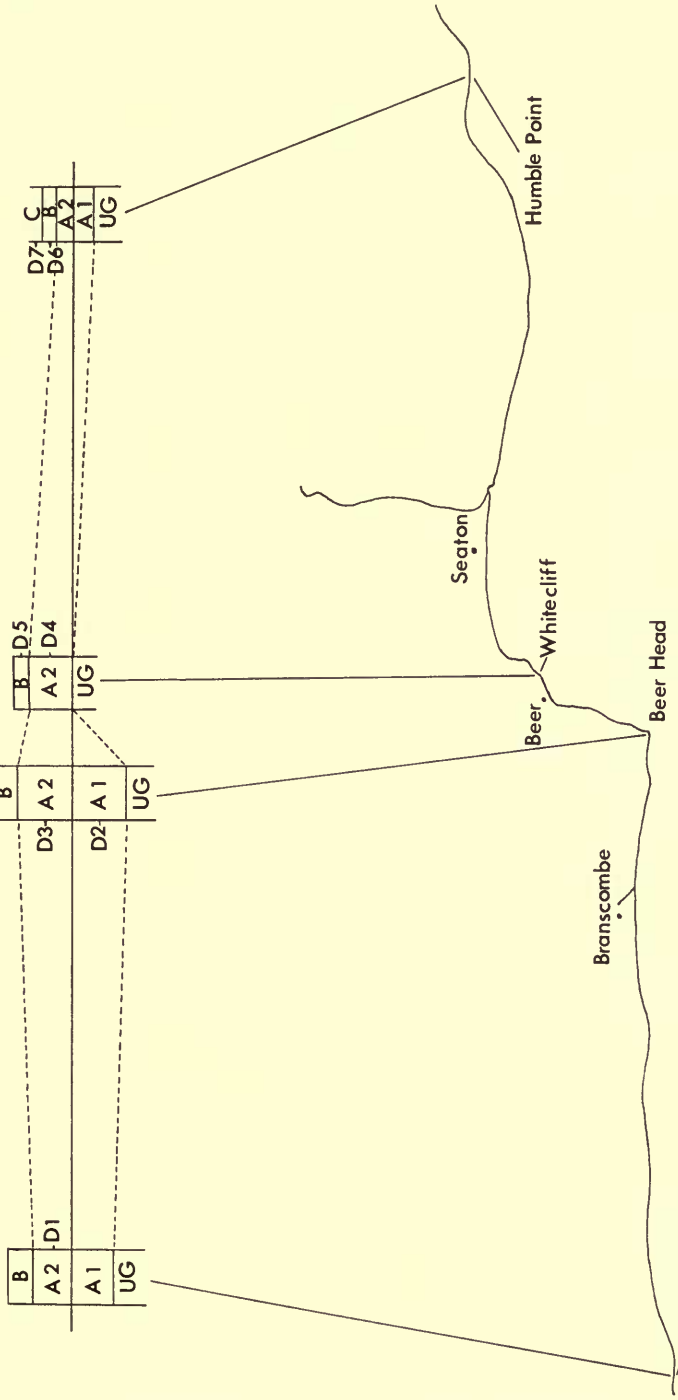

FIG. 6. Map and Section showing the Location of the Samples analysed from Devon (south coast). Scale 1 inch to 16 feet.

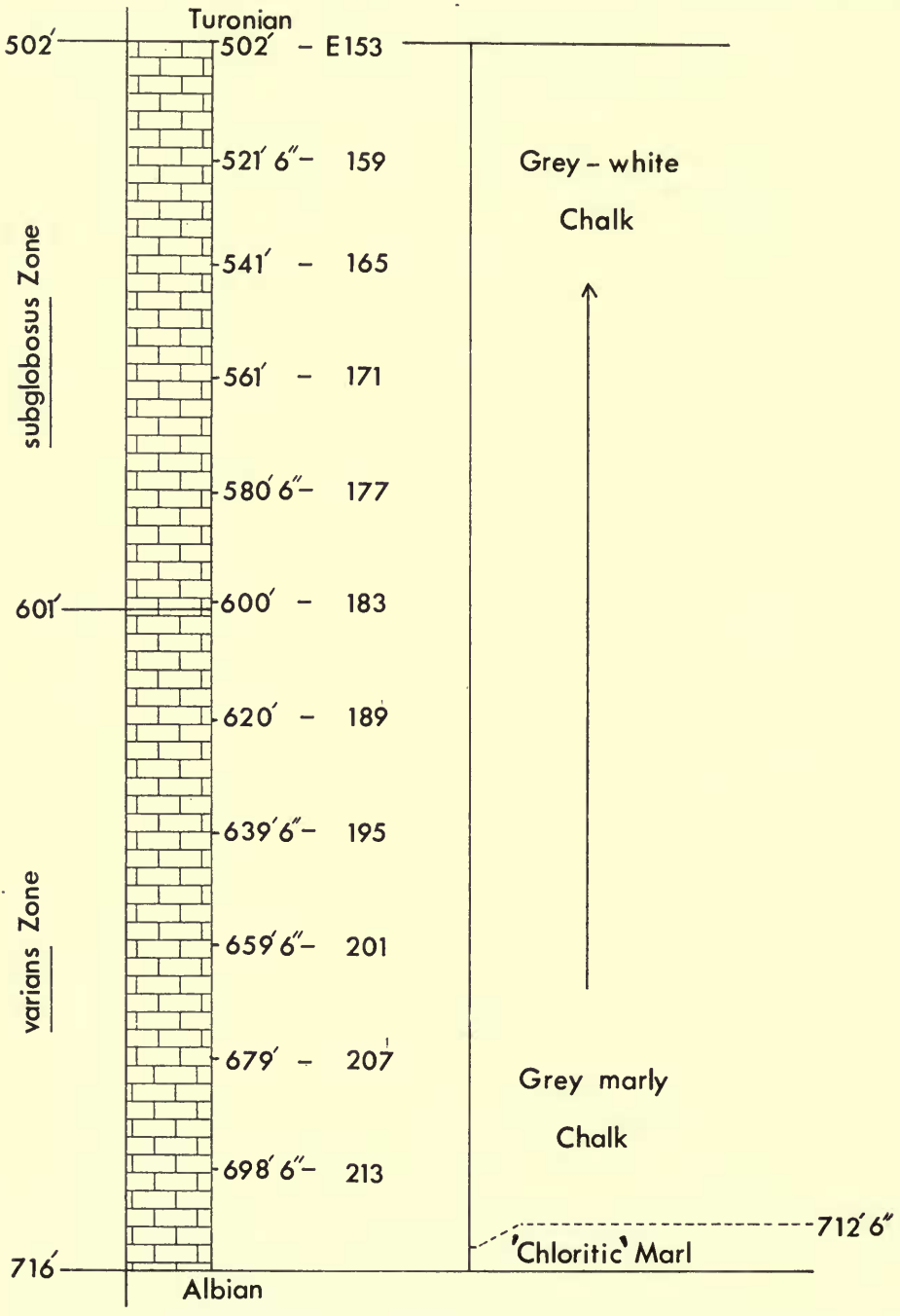

FIG. 7. Section showing the Location of the Samples analysed from Escalles, France. Scale 1 inch to 30 feet.

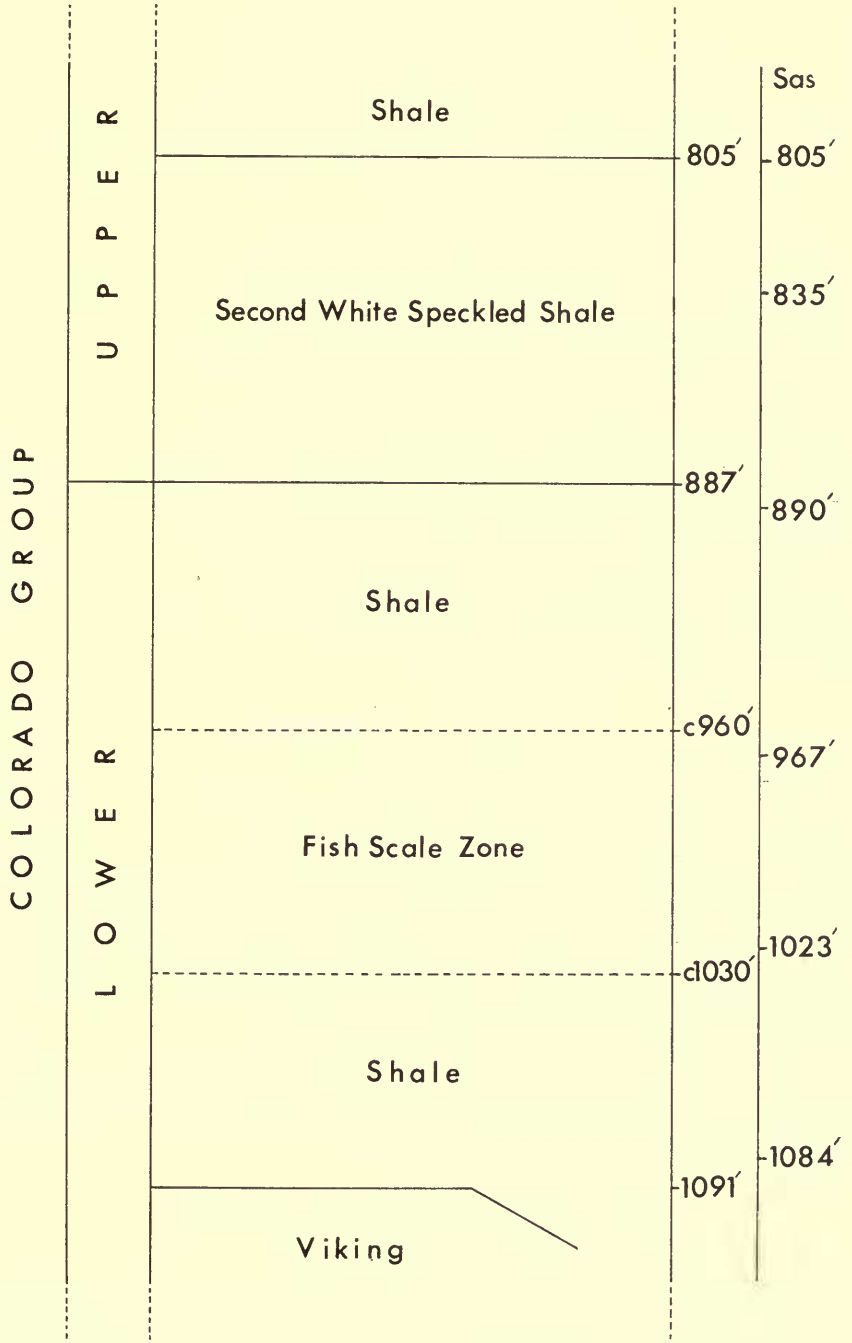

FIG. 8. Section showing the Location of the Samples analysed from Saskatchewan, Canada. Scale 1 inch to 50 feet.

III. SYSTEMATIC DESCRIPTIONS

Class *DINOPHYCEAE* Pasher

Subclass *DINIFEROPHYCIDAE* Bergh

Cyst-Family **GONYAULACYSTACEAE** Sarjeant & Downie 1966

Genus ***GONYAULACYSTA*** Deflandre emend. Sarjeant 1966

Gonyaulacysta cassidata (Eisenack & Cookson) emend. Sarjeant

1960 *Gonyaulax helicoidea* subsp. *cassidata* Eisenack & Cookson : 3, pl. 1, figs. 5, 6.
1966*a* *Gonyaulacysta cassidata* (Eisenack & Cookson) Sarjeant : 125, pl. 14, figs. 3, 4, text-fig. 31 (see also for earlier references).
1967 *Gonyaulacysta cassidata* (Eisenack & Cookson) Clark & Verdier: 29, pl. 4, figs. 4–6.

Dimensions. Range of observed specimens: overall length 59 (67·5) 78 μ, overall width 40 (46·4) 60 μ. Number of specimens measured, 14.

Remarks. The Cenomanian specimens examined are very similar to the Australian Aptian-Cenomanian forms of Eisenack & Cookson (1960) and Cookson & Eisenack (1962*b*) except that the former are slightly smaller in size.

Occurrence. *G. cassidata* is an infrequent species at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has not been recorded in the North American samples.

Gonyaulacysta whitei Sarjeant

1966*a* *Gonyaulacysta whitei* Sarjeant : 126, pl. 14, fig. 2, text-fig. 32.

Dimensions. Range of observed specimens: overall length 55–62 μ, overall width 42–50 μ. Number of specimens measured, 5.

Remarks. The shape of the shell, the tabulation and the crests make *G. whitei* an easily recognizable and distinctive species. *G.* cf. *ambigua* Cookson & Eisenack (1960*b*) from the Upper Jurassic is of the same shape and possesses similar crests and tabulation; plate 1'''' is absent. However, the apical horn of *G.* cf. *ambigua* is rudimentary or absent, thus making differentiation easy.

Occurrence. Of five specimens of *G. whitei* observed, four are from sample FM 770 and one from sample FM 750. The restricted distribution of this species and its similarity to *G.* cf. *ambigua* from the Upper Jurassic suggest the possibility that this is a derived form.

Gonyaulacysta fetchamensis Sarjeant

1966*a* *Gonyaulacysta fetchamensis* Sarjeant : 128, pl. 15, figs. 1, 2, text-fig. 33.

Remarks. *G. fetchamensis* has a rather unusual tabulation—two posterior intercalary plates and a seventh postcingular plate—and, as pointed out by Sarjeant (1966*a*), may subsequently form the basis of a new genus. As yet only two specimens have been studied and this species has, therefore, been placed in *Gonyaulacysta*. It

appears to be a transitional type from the normal *Gonyaulacysta* to forms now placed in *Cribroperidinium* Neale & Sarjeant. The latter forms are of similar overall appearance but the shell is divided by low crests into an unusually large number of areas.

Occurrence. *G. fetchamensis* is a rare species recorded only from the Chalk of H.M. Geological Survey borehole, Fetcham Mill, Surrey, at 840 ft. depth. Upper Cretaceous (Lower Cenomanian).

Gonyaulacysta exilicristata sp. nov.

(Pl. 1, figs. 1, 2; Figs. 9A, B)

Derivation of name. Latin, *exilis*, thin or poor; *cristatus*, crested—with reference to the poorly defined sutural crests.

Diagnosis. Shell subspherical; moderately well developed apical horn. Shell wall thick, finely but densely granular. Reflected tabulation 3′, 1a, 6″, 6c, 6‴ (—7‴?), 1 p, 1⁗. Plate boundaries marked by low, poorly defined crests which sometimes form small spines at crestal nodes. Cingulum narrow, weakly laevorotatory; sulcus of moderate width, widening slightly posteriorly.

Holotype. G.S.M. slide PF 3987 (1). Lower Chalk, H.M. Geological Survey Borehole, Fetcham Mill, Surrey at 730 ft. depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: overall length 83 μ, overall width 68 μ, length of horn 12 μ. Range: overall length 70 (81·6) 98 μ, overall width 58 (64·5) 71 μ. Number of specimens measured, 24.

Description. The shell wall measures between 2 and 3 μ in thickness, the endophragm being approximately twice as thick as the periphragm. The latter forms the apical horn which is triangular in cross-section due to the sutural ridges which delimit the apical plates extending along it. Lines of ornamentation, sometimes similar to the sutural crests, are present on some of the plates, particularly those in the postcingular series. Occasionally it appears that plate 4‴ is subdivided by a low ridge so giving seven postcingular plates.

The cingulum is fairly narrow (3 to 4 μ) and only slightly laevo-rotatory. The sulcus often possesses a posterior ventral plate. In the medial-posterior part of the furrow there is usually an elongate depression, as seen in the holotype (Fig. 9A). A precingular archaeopyle is typically present.

Remarks. *G. exilicristata* sp. nov. is distinguished from all previously described species by its overall shape, the type of plate boundaries and the tabulation. *Apteodinium granulatum* Eisenack (1958) is similar but has a stouter apical horn and a tabulation appears to be absent; the cingulum is only rarely visible.

Cribroperidinium orthoceras (Eisenack) comb. nov. is also similar but possesses a longer apical horn, and the tabulation differs and is more clearly defined.

Occurrence *G. exilicristata* is a rare species recorded from a number of horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. At only one horizon is this species common, in sample FM 730 from Fetcham Mill. Two specimens have been recorded from Saskatchewan, both from sample Sas 1084.

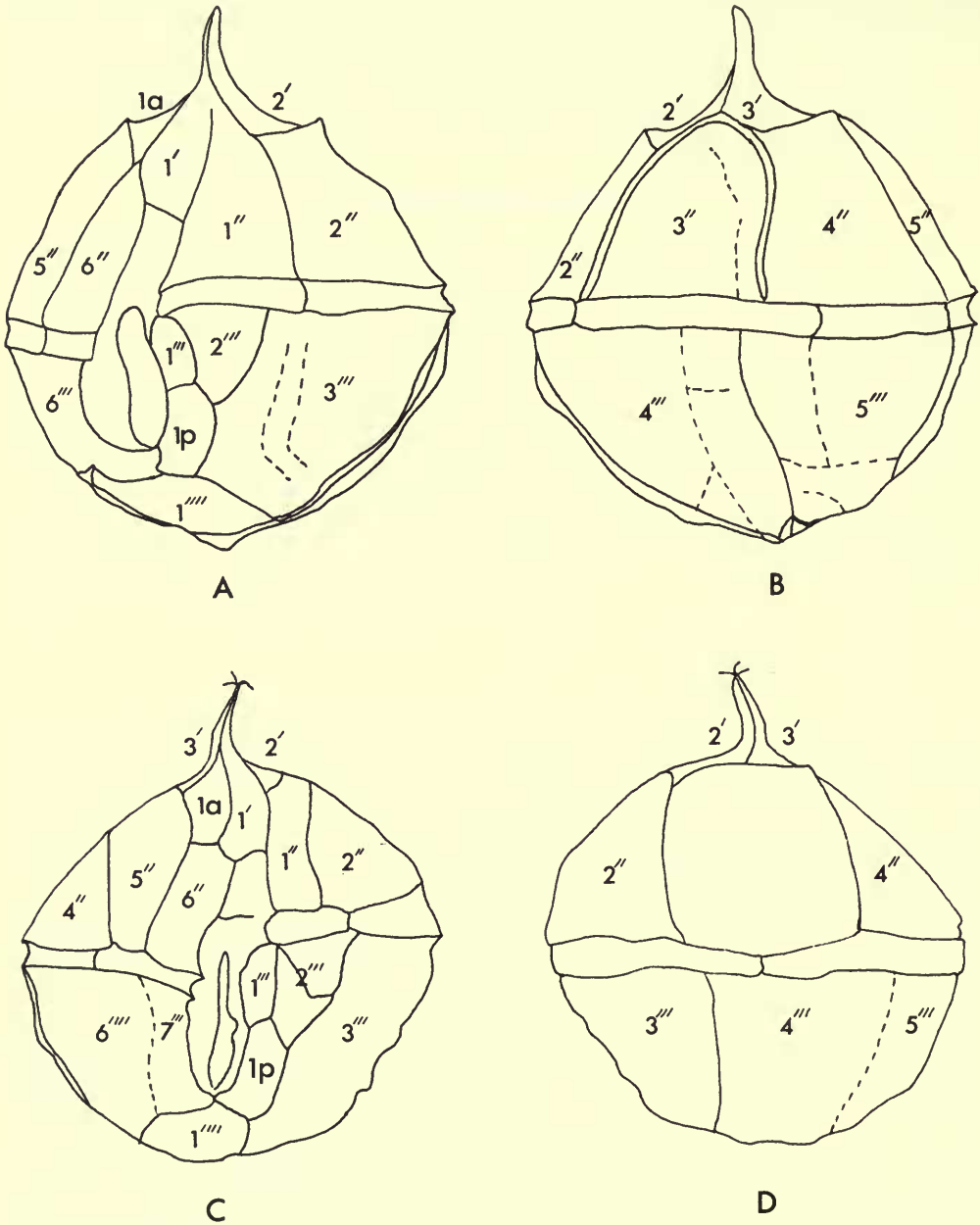

FIG. 9. *Gonyaulacysta exilicristata* sp. nov., A. Ventral Surface of Holotype (× 900), B. Dorsal Surface of Holotype, (× 900). *Gonyaulacysta* Sp. A., C. Ventral Surface slide PF. 3987 (2) (× 900). D. Dorsal Surface slide PF. 3987 (2) (× 900).

Gonyaulacysta delicata sp. nov.

(Pl. 1, figs. 7, 8; Figs. 10A, B)

Derivation of name. Latin, *delicatus*, delicate—with reference to the delicate nature of the shell.

Diagnosis. Shell subspherical, epitract and hypotract of similar size. Shell wall thin, smooth. Apical horn absent, there being a small circular apical plate in this position surrounded by three large apical plates. Reflected tabulation 4′, 1a, 6″, 6c, 6‴, 1p, 1⁗. Plate boundaries well defined by low crests. Cingulum wide, strongly laevo-rotatory; sulcus broad.

Holotype. B.M. (N.H.) V. 51979(1). Lower Colorado, Second White Speckled Shale, International Yarbo Borehole No. 17, Saskatchewan at 835 ft. depth. Upper Cretaceous (Cenomanian).

Paratype. B.M. (N.H.) V. 51979(2).

Dimensions. Holotype: length of shell 57 μ, width 51 μ. Paratype: length of shell 55 μ, width 47 μ. Range: length of shell 52–60 μ, width 47–51 μ. Number of specimens measured, 4.

Description. The shell wall is very thin (less than 0·5 μ thick) and only attains a thickness of 0·5 μ when forming the plate boundaries. Due to the thinness of the shell wall specimens are easily distorted. The tabulation has, however, been formulated after the examination of a number of specimens.

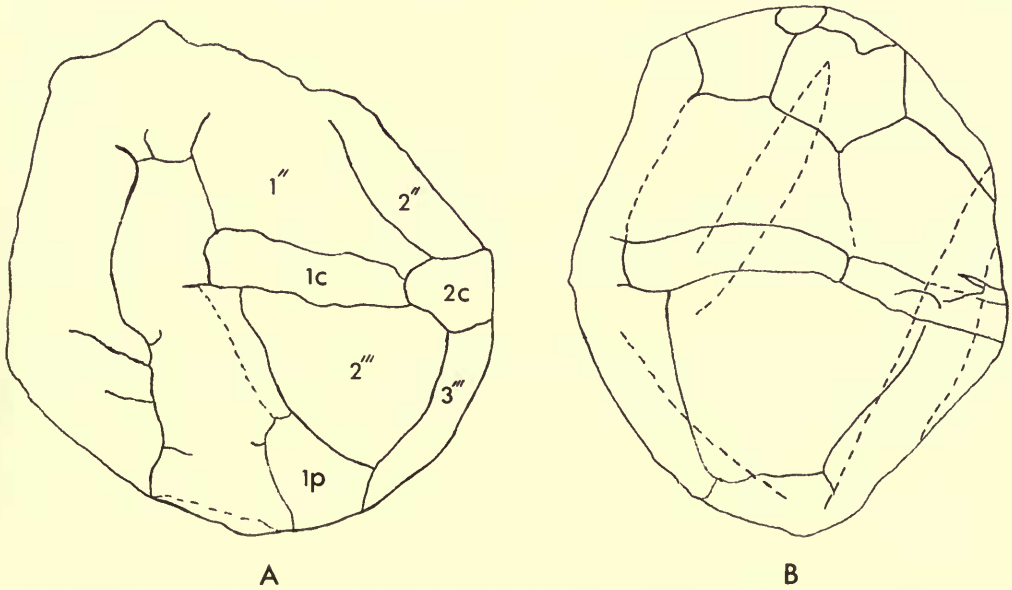

Fig. 10. *Gonyaulacysta delicata* sp. nov., A. Ventral surface of Holotype (× 1500). B. Dorsal surface of Holotype (× 1500).

Anteriorly three apical plates (2′, 3′ and 4′) abutt against a small circular plate, plate 1′, which is in the position normally occupied by the apical horn. The precingular and postcingular series of plates are large and more or less pentagonal. Plate 3″ is always lost in archaeopyle formation. The first postcingular plate is elongate and has a poorly defined sulcal border.

The cingulum is wide (4 to 7 μ) and tends to be constricted at the cingular plate boundaries. The sulcus is broad and widens slightly towards the posterior. The anterior end of the sulcus has a flat margin from which arise plates 1′ and 1a. At the posterior end of the sulcus there may be developed a posterior ventral plate.

Remarks. The presence of very low sutural crests, the lack of an apical horn and the tabulation differentiate *G. delicata* sp. nov. from all previously described species. *G. ambigua* Deflandre, from the Kimeridgian of France, is of similar appearance but possesses a small apical horn and differs in tabulation detail.

Occurrence. *G. delicata* has been found in only one sample, Sas 835, and it is there infrequent. This restricted distribution may well indicate that this is a derived species.

Gonyaulacysta sp. A.

(Pl. 1, figs. 9, 10; Figs. 9C, D)

Description. Only one well preserved specimen of this species has so far been observed. It possesses a subspherical shell, bearing a moderately well developed horn with a trifid termination. The shell wall (*c.* 2 μ thick) is irregularly studded with granules of varying shapes and sizes. The sutural crests are quite well defined, but low, and indicate a reflected tabulation of 3′, 1a, 6″, 6c, 6‴ (—7‴?), 1p., 1⁗. The crests, demarcating the three apical plates, extend along the apical horn and give rise to three small spines at its distal termination. Plates 2″, 3″ and 4″ are relatively large, plates 1″ and 5″ rather elongate and plate 6″ is reduced due to the anterior intercalary plate. In the postcingular series, plates 1‴ and 2‴ are reduced and plate 7‴ does not have a clearly marked plate boundary. Plate 2‴ possesses a curved line of ornamentation which is characteristic of *Cribroperidinium* Neale & Sarjeant. There is a single posterior intercalary plate and a large antapical plate.

The cingulum is strongly laevo-rotatory and varies considerably in width (2–5 μ), being constricted at the cingular plate boundaries and expanding on either side. The sulcus is broad and possesses a central depressed area of elongate shape. A archaeopyle is present.

Figured Specimen. G.S.M. slide PF. 3987, specimen 2. Lower Chalk, H.M. Geological Survey Borehole, Fetcham Mill, Surrey at 730 feet depth, Upper Cretaceous (Cenomanian).

Dimensions. Overall length 75 μ, overall width 65 μ, length of horn 14 μ.

Remarks. The form of the apical horn, the type of granulation and the shape of the cingular plates distinguish this species from all described forms. The shape

of the shell and the tabulation are most comparable to *G. exilicristata* suggesting a relationship between the two species.

Genus ***CRIBROPERIDINIUM*** Neale & Sarjeant emend.

EMENDED DIAGNOSIS. Proximate cysts, subspherical to ovoidal, thick-walled. Crests numerous and well developed. Tabulation ?6′, (1–5a), 8–9″, oc, 9‴, 1p, 1–3p.v. (5–7 p.c.), o′′′′ (—?2′′′′). Cingulum laevo-rotatory. Archaeopyle precingular.

TYPE SPECIES. *Cribroperidinium sepimentum* Neale & Sarjeant 1962.

REMARKS. The diagnosis has been emended to draw attention to the fact that the anterior intercalary series and the posterior circle series of plates are not always readily distinguishable. The tabulation attributed to this genus by Neale & Sarjeant was 6′, 1–5a, 8″, 9‴, 1p, 1–2p.v. 6–?7p.c., o′′′′. In determining the tabulation they numbered all the delimited areas on the shell surface in the normal manner. This numbering procedure has been used in the study of *C. intricatum* sp. nov. with certain reservations. Difficulties arose due to the large number of delimited areas and also to some variation on the dorsal surface of the hypotract. Some of the crests are rudimentary and others, although appearing fairly normal, are unusual in their position. It was discovered that by the removal of these unusual crests a normal *Gonyaulax*-type tabulation could be reconstructed. This is clearly shown in Figs. 11A, B, of the ventral surface of the holotype of *C. intricatum*. Thus *Cribroperidinium* is basically a form of *Gonyaulacysta* which possesses additional crests. These additional crests may correspond to an increase in the number of thecal plates composing the motile dinoflagellate, but this is thought to be unlikely since:

(a) the plates formed would be of an extremely unusual shape;

(b) these crests subdivide detached opercula demonstrably composed of a single precingular plate (3″);

(c) many of these crests are poorly developed and show considerable positional variation on the dorsal surface of the hypotract; and

(d) that by their removal a normal *Gonyaulax*-type tabulation remains. Thus, these additional crests may be regarded as an ornamentation or perhaps a rather, superficial cyst strengthening device. It is, therefore, considered more practical and correct to use a different numbering system for the *Cribroperidinium* cyst tabulation, *vis*, roman numerals.

Three species, *Gonyaulacysta orthoceras* (Eisenack), *G. muderongensis* (Cookson & Eisenack) and *G. edwardsi* (Cookson & Eisenack), are here transferred to *Cribroperidinium*. This genus appears to be very limited in stratigraphic range (Hauterivian—Lower Turonian) and, as such, is a useful stratigraphic indicator.

Cribroperidinium intricatum sp. nov.

(Pl. 2, figs. 1–3; Figs. 11, 12)

DERIVATION OF NAME. Latin, *intricatus*, complicated—with reference to the complex crest arrangement.

DIAGNOSIS. Shell subspherical, epitract and hypotract of similar size. Apical horn of moderate length, subconical. Shell wall moderately thick, granular and bears a few, randomly arranged tubercles. Crests usually in form of low ridges, well defined, sometimes membranous, delimiting a large number of plates on shell surface. Sutural spines absent. Plate II‴ crossed diagonally by low crest. Operculum possessing semi-circular crest. Sulcus possessing posterior ventral plates. Cingulum narrow, plates not defined.

HOLOTYPE. B.M. (N.H.). V. 51980 (1). Upper Lower Colorado, Fish Scale Zone, International Yarbo Borehole No. 17, Saskatchewan at 1,023 feet depth. Lower Cretaceous (Albian).

DIMENSIONS. Holotype: overall length 120 μ, overall width 114 μ, length of horn 20 μ. Range: overall length 107 (125·1) 142 μ, overall width 101 (108·2) 126 μ. Number of specimens measured, 17.

DESCRIPTION. The shell wall is 1 to 1·5 μ in thickness and densely granular. The crests are typically low thickenings of the periphragm (2–3 μ wide), but in the antapical region, and occasionally elsewhere, the crests take the form of high flanges The latter (up to 6 μ in height) are membranous, thin and always perforate.

The number of apical plates always appears to be six. Plate I′, equivalent to the first apical plate, is elongate and abuts against the anterior end of the sulcus. The crest arrangement on the ventral surface appears to be practically constant and is characteristic of this species. The crests limiting the plates I′, I″, II″, III″, IV″, VII″ and VIII″ are always constant in position. Plates I‴ and II‴ are reduced due to the presence of a posterior intercalary plate. Plate II‴ always possesses a crest passing diagonally across it and the crest between plates III‴ and IV‴ is of a

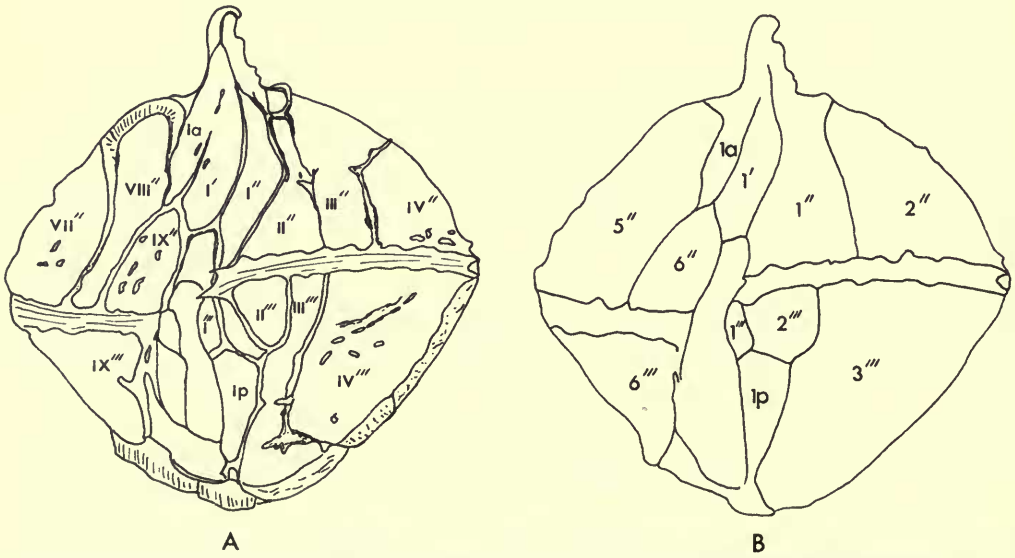

FIG. 11. *Cribroperidinium intricatum* sp. nov. A. Ventral surface of Holotype, (× 700). B. Reconstruction to show *Gonyaulax*-type tabulation (× 700).

characteristic right angle shape. The positions of the crests on the dorsal surface of the epitract are fairly constant, only varying in minor details. The large plate V″ is usually detached in archaeopyle formation and possesses a semi-circular crest from which radiate a small number of other crests (Pl. 2, fig. 3). These pass over the boundary of plate V″ to continue on adjacent parts of the epitract. The positions of the crests on the dorsal surface of the hypotract appear to be less constant in position. Their predominent direction is parallel to the longitudinal axis of the shell; sometimes a series of posterior circle plates may be present. Antapical plates, if present at all, are very reduced and obscured by the crestal membranes.

The cingulum is narrow (*c.* 6 μ in width), slightly laevo-rotatory, and tends to possess a thicker wall than is usual for the remainder of the shell. The sulcus only projects onto the epitract for a short distance, being considerably larger and wider on the hypotract. It is always divided into a number of posterior ventral plates by reduced crests.

Remarks. Figs 11B, 12B have been prepared from the holotype and one other specimen, omitting the additional crests, to show the basic *Gonyaulax*-type tabulation.

C. intricatum may be differentiated from *C. orthoceras* (Eisenack), *C. muderongensis* (Cookson & Eisenack), *Gonyaulacysta apionis* and *G. diaphanis* by its more spherical form, details of crest arrangement and the absence of spines. *C. edwardsi* (Cookson & Eisenack) is most similar, being almost spherical, but possesses a very well developed, stiff apical horn and the crests on the ventral surface are arranged differently. In particular the diagonal crest on plate II‴ is absent. *Gonyaulax* sp. (Górka 1963) from the Cenomanian of Poland is very similar and may be conspecific with *C. intricatum*.

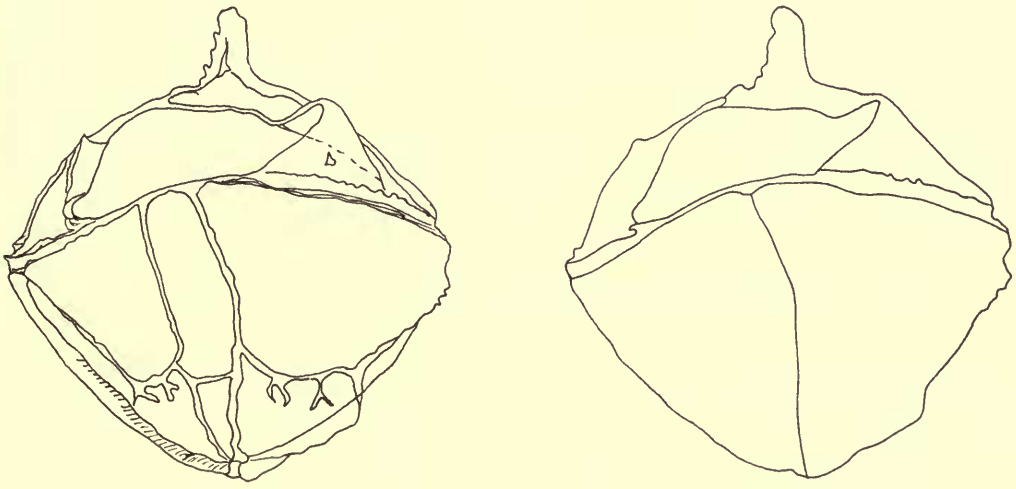

Fig. 12. *Cribroperidinium intricatum* sp. nov., A. Dorsal surface of Holotype with archaeopyle (× 700). B. Reconstruction to show *Gonyaulax*-type tabulation (× 700).

Occurrence. *C. intricatum* is very rare in the British Cenomanian and has been observed only in samples FM 840, CB 1 and CB 7. At Escalles it is infrequent in sample E 201, very rare in sample E 195 and lacking elsewhere. In the Saskatchewan sample Sas 1023 it is common, in sample Sas 1084 rare and is lacking in all the other North American samples. It is interesting to record that this species was observed in the Albian sample FM 886 from Fetcham Mill. Thus *C. intricatum* has a range from Albian to Lower Cenomanian in the examined material.

OTHER SPECIES

The following species are here attributed to the genus *Cribroperidinium* on the basis of overal shape, and number and position of periphragm crests:—

Cribroperidinium orthoceras (Eisenack 1958) comb. nov., 1958 *Gonyaulax orthoceras* Eisenack, Neues. Jb. Geol. Paläont., Abh., **106** (3) 388: pls. 21, figs. 3–14; 24, fig. 1; text-figs. 2, 3.
Cribroperidinium edwardsi (Cookson & Eisenack 1958) comb. nov., 1958 *Gonyaulax edwardsi* Cookson & Eisenack: Proc. R. Soc. Vict., **70** (1), 32–33; Pl. III, figs. 5, 6, text-fig. 7.
Cribroperidinium muderongensis (Cookson & Eisenack 1958) comb. nov., 1958 *Gonyaulax muderongensis* Cookson & Eisenack: Proc. R. Soc. Vict., **70** (1), 32; Pl. III, figs. 3, 4, text-fig. 15.

Gonyaulacysta apionis (Cookson & Eisenack 1958) and *G. diaphanis* (Cookson & Eisenack 1958), both from the Lower Cretaceous of Australia, are of similar appearance to forms included in *Cribroperidinium* and may at a later date be transferred to this genus.

Eisenack (1958 text-figs. 2, 3) figured the ventral surface tabulation of *C. orthoceras* omitting, or dotting in, some of the crests which are seen to be present on the photographs of the same specimens. Thus a true representation of the crestal positions was not given, somewhat misleading later workers. These figures have been redrawn (Figs. 13A, B) from the photographs and show the remarkable similarity between the ventral surface of *C. orthoceras* and that of *C. intricatum*. For this reason the former species has been transferred to *Cribroperidinium* and the diagnosis emended. Eisenack does in fact compare and contrast his species with the reattributed Australian forms above, also with *Gonyaulactysa wetzeli* (Lejeune Carpentier 1939) and *G. obscura* (Lejeune-Carpentier 1946), all of which he considers to be in the same group. The latter two species, however, have a typical *Gonyaulacysta* tabulation and must remain in that genus.

Cribroperidinium orthoceras (Eisenack) emend.

(Figs. 13A, B)

1958 *Gonyaulax orthoceras* Eisenack : 388, pl. 21, figs. 3–14, pl. 24, fig. 1; text-figs. 2, 3.
1959 *Gonyaulax orthoceras* Eisenack; Gocht : 54, pl. 5, figs. 12, 13.
1961 *Gonyaulax orthoceras* Eisenack; Alberti : 6, pl. 11, figs. 1–3.
1963 *Gonyaulax orthoceras* Eisenack; Górka : 30, pl. 3, figs. 1–4.
1965 *Gonyaulax orthoceras* Eisenack; Balteş : 12, pl. 3, figs. 95–99.

Emended diagnosis. Shell ovoidal, moderately thick-walled, bearing strong, thorn-like apical horn constituting approximately one quarter of shell length. Shell

wall granular bearing tubercles. Distinct tabulation marked by strong, low crests delimiting large number of plates. Plate II''' crossed diagonally by low crest and operculum possessing semi-circular crest. Cingulum narrow, devoid of plate boundaries.

Holotype. The specimen illustrated by Eisenack (1958, pl. 21, fig. 5) from Preparation Ob. Apt. No. 32. Aptian glauconitic limestone, Deutschen Erdol A. G., Erdolwerke Holstein boring Marne, Feld Heide, North Germany, at 761·7 metres depth.

Remarks. The emended diagnosis excludes those forms described by Sarjeant (1966) from the Speeton Clay which are to be described elsewhere under a new specific name.

Genus ***CARPODINIUM*** Cookson & Eisenack, 1962

Carpodinium obliquicostatum Cookson & Hughes

(Pl. 1, figs. 3, 4)

1964 *Carpodinium obliquicostatum* Cookson & Hughes : 48, pl. 6, figs. 1–6.
1967 *Carpodinium obliquicostatum* Cookson & Hughes; Clarke & Verdier: 23, pl. 2, figs. 4, 5.

Description. The shell is elongate-ovoidal and bears relatively high sutural crests. The latter are smooth or slightly granular and the distal margin may be entire or spinous. The short apical horn is a prolongation of one of the larger crests and is typically asymmetrically placed. The periphragm of the shell possesses an unusual ornamentation—small areas of triangular to polygonal shape, composed of thick periphragm, are separated by narrow anastomosing " canals " where the periphragm is unthickened or perhaps absent (Pl. 1, fig. 4).

The cingulum is marked by indentations in some of the crests and is not apparent on the shell surface. The sulcus, delimited by crests, is occasionally observable and extends the length of the shell, being narrow near the apex and widening posteriorly. The precingular and postcingular plates, probably six in each series, are very elongate and difficult to discern because of the obscuring nature of the high crests. A precingular archaeopyle is commonly present. Four apical plates and a single antapical plate appear to be present. Intercalary plates were not observed.

Dimensions. Range of observed specimens: overall length 56(69·5) 82 μ, overall width 33(43·8) 57 μ, height of crests 6–15 μ. Number of specimens measured, 16.

Remarks. The Cenomanian specimens studied resemble the type material from the Upper Albian and Lower Cenomanian of Cambridgeshire in all respects.

Occurrence. *C. obliquicostatum* is a rare to very rare species found at all horizons throughout the Cenomanian of Fetcham Mill and Compton Bay and in three samples from Escalles (E 195, E 189 and E 159).

Genus ***ELLIPSODINIUM*** Clarke & Verdier 1967

Remarks. A number of microplankton genera have been described as possessing a reticulate shell wall, occasionally with an outer membrane but only rarely with any

signs of tabulation. In all the described forms possessing a cingulum the archaeopyle is apical. Hence the combination of numerous crests, a cingulum and a precingular archaeopyle differentiates *Ellipsodinium* from all previously described genera.

Ellipsodinium rugulosum Clarke & Verdier

(Pl. 3. fig. 1; Figs. 14C, D)

1967 *Ellipsodinium rugulosum* Clarke & Verdier: 69, pl. 14, figs. 4–6, text-fig. 29.

Dimensions. Range of observed specimens: shell length 30 (37.7) 46 μ, shell width 25 (33·6) 40 μ, maximum height of crests 1·5 (2·4) 3·5 μ. Number of specimens measured, 20.

Description. The crests are thin, occasionally perforate lamellar structures which thicken slightly before joining the shell surface. The cingulum may be delimited by a pair of crests, or in the absence of cingular crests, crests may terminate abruptly at its borders. Rarely crests traverse the cingulum. The sulcus is not obvious because of the nature of the elongate areas outlined by the crests. Apical and antapical processes or horns are absent. The precingular archaeopyle is subtriangular in outline.

Occurrence. *E. rugulosum* is a rare to fairly common species at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It was not observed in the North American material.

Cyst-Family **PAREODINIACEAE** Gocht emend. Sarjeant & Downie 1966

Genus ***APTEODINIUM*** Eisenack 1958

Remarks. Members of this genus have occasionally been observed in the European Cenomanian and have been placed in *A. granulatum*. Rarely plate boundaries may be discernable. This fact together with the overall shape and the well developed precingular archaeopyle indicate that this genus is closely related to *Gonyaulacysta* and at a future date may be transferred to the Cyst-Family *Gonyaulacystaceae*.

Apteodinium granulatum Eisenack

(Pl. 3, figs. 5, 6)

?1935 *Palaeoperidinium ventriosum* O. Wetzel; Deflandre : 228, pl. 5, fig. 5; pl. 6, figs. 9, 10.
?1936*b* *Palaeoperidinium ventriosum* O. Wetzel; Deflandre : 27, pl. 5, figs. 1–4.
?1936*a* *Palaeoperidinium ventriosum* O. Wetzel; Deflandre: fig. 100.
1958 *Apteodinium granulatum* Eisenack : 386, pl. 23, figs. 8–14, text-fig. 1.
1958 *Apteodinium granulatum* Eisenack; Gocht : 64, pl. 5, fig. 2.
1961 *Apteodinium granulatum* Eisenack; Alberti : 24, pl. 4, figs. 4–6.
1963 *Apteodinium granulatum* Eisenack; Balteş : 584, pl. 4, fig. 11.

Description. Shell subspherical with a moderately thick wall (1–2·5 μ) and possessing a stout conical horn. The wall is densely granular, the granules often being elongated into fine, short processes which are linked laterally thus covering

the shell surface with an intricate network of a matted furry appearance. The cingular boundaries are always visible as slight thickenings of the periphragm. Very rarely similar but more reduced thickenings indicate the presence of plate boundaries. A precingular archaeopyle is commonly developed.

Dimensions. Range of observed specimens: overall length 42 (48·2) 53 μ, width 31 (38·6) 44 μ, length of apical horn 5 (6·1) 8 μ. Number of specimens measured, 9.

Remarks. The Cenomanian specimens are very similar in appearance to the type material described by Eisenack from the Aptian of Germany. The matted, furry appearance was not described but when this feature is only slightly developed the shell wall merely appears to be very granular. The Aptian and Cenomanian examples of *A. granulatum* appear to be comparable to *Palaeoperidinium ventriosum* O. Wetzel as illustrated by Deflandre (1935, 1936*a*, *b*). The holotype of this species has been re-examined by Lejeune-Carpentier (1946) and a distinct tabulation described. Deflandres' forms which do not possess a tabulation are hence here tentatively reattributed to *A. granulatum*.

Occurrence. Only two specimens have been recorded from the English Cenomanian, both from sample FM 690. At Escalles two specimens have been recorded from both samples E 183 and E 153, and three from sample E 165. *A. granulatum* is fairly common in sample FM 886 (Albian) from Fetcham Mill but is absent in the North American material and from sample FM 520 (Turonian).

Genus ***TRICHODINIUM*** Eisenack & Cookson emend. Clarke & Verdier

Remarks. This genus differs from *Exochosphaeridium* Davey, Downie, Sarjeant & Williams (1966) by the presence of a well developed cingulum and by the shorter spines.

Trichodinium castaneum (Deflandre)

Pl. 11, figs. 1–3

1935 *Palaeoperidinium castanea* Deflandre : 49, pl. 6, fig. 8.
1936*b* *Palaeoperidinium castanea* Deflandre; Deflandre : 25, pl. 16, figs. 1–4.
1936*a* *Palaeoperidinium castanea* Deflandre; Deflandre: fig. 99.
1952*b* *Palaeoperidinium castanea* Deflandre; Deflandre: fig. 96.
1962*b* *Palaeoperidinium castanea* Deflandre; Cookson & Eisenack : 489, pl. 3, figs. 9–11.
1964 *Palaeoperidinium castanea* Deflandre; Cookson & Hughes : 49, pl. 5, fig. 14.
1967 *Trichodium castanea* (Deflandre) Clarke & Verdier: 19, pl. 1, figs. 1, 2.

Description. The shell is subspherical with occasionally a small apical horn or a tuft of apical spines. The shell wall is slightly punctate and bears numerous small spines. These are solid, often bifurcate either proximally or distally, and typically terminate in a small bifurcation. Rarely they may be acuminate. The cingulum (3–5 μ in width) is marked by two parallel lines of thickening along which spines are concentrated. Lines of similar thickening sometimes occur perpendicularly to the cingulum and are probably sutural. A sulcus has not been observed. A precingular archaeopyle is commonly present.

Dimensions. Range of observed specimens: shell diameter 35 (49·0) 64 μ, length of spines 1 (3·3) 5 μ. Number of specimens measured, 16.

Remarks. The Cenomanian specimens resemble the type material from the Upper Cretaceous of France in all respects. The presence of a precingular archaeopyle, an apical prominence or apical spines, and a well developed cingulum indicate that this species should be placed in *Trichodinium*. *T. intermedium* Eisenack & Cookson, from the Aptian to Lower Albian of Australia, is very similar but is larger (shell diameter 69–90 μ).

Occurrence. *T. castaneum* is a rare species occurring at most horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has not been recorded from the North American samples. This species has a recorded stratigraphic range from the Aptian to the Senonian (Deflandre).

Cyst-Family **MICRODINIACEAE** Eisenack emend. Sarjeant & Downie 1966

Genus ***MICRODINIUM*** Cookson & Eisenack emend. Sarjeant 1966

Remarks. *Microdinium* differs from *Gonyaulacysta* primarily in possessing a single apical plate which is detached in archaeopyle formation. Górka (1965), in describing Upper Jurassic assemblages, erected the genus *Tetrasphaera* which is diagnosed as having a feebly marked tabulation and short spines on the plate boundaries. Górka has since stated (personal communication with Dr. W. A. S. Sarjeant) that this genus differs from *Microdinium* only in these two respects. However, it follows that if the tabulation is not clear it is difficult to compare this new genus with *Microdinium* or any other genus possessing a tabulate cyst, since the diagnosis of these genera is primarily based on the observed tabulation. Also, spines have been observed on the plate boundaries of *Microdinium*, even in the type species. Thus it would appear that *Tetrasphaera* at the moment is not precisely defined.

Microdinium cf. ***ornatum*** Cookson & Eisenack.

(Pl. 4, fig. 5; Figs. 13C, F)

1966*a* *Microdinium* cf. *ornatum* Cookson & Eisenack; Sarjeant : 149, pl. 16, figs. 3–6, text-fig. 38.
1967 *Microdinium ornatum* Cookson & Eisenack; Clarke & Verdier: 66, pl. 5, figs. 11–14.

Description. The shell is subspherical to ovoidal possessing a smooth body wall ornamented by a few large tubercles. The latter may be flat or distinctly concave distally. In two specimens small tubercles were seen to delimit a plate in the posterior portion of the ventral area. The plates are bordered by short, broad projections (Fig. 13F), which may be isolated or united distally.

Dimensions. Range of observed specimens: shell length 31–34 μ, width 23–31 μ, height of crests 1–2 μ. Number of specimens measured, 6.

Remarks. *M.* cf. *ornatum* differs from *M. ornatum* Cookson & Eisenack (1960*a*) in that (i) the small cingular plate, ventral to plate 6c, is absent or has a very reduced ventral suture, and (ii) the plates are not bordered by ledges, which are sometimes perforate, but by isolated tubercles and spines.

Occurrence. *M.* cf. *ornatum* is a rare species in the material examined being found only in the following samples: FM 810, FM 670, FM 650, FM 520 (Turonian), E 189 and E 153. In Australia *M. ornatum* has a stratigraphic range from the Albian to the Lower Turonian.

Microdinium setosum Sarjeant.

(Pl. 2, fig. 4; Fig. 13H)

1966 *Microdinium setosum* Sarjeant : 151, pl. 16, figs. 9, 10; text-fig. 39.
1967 *Microdinium echinatum* Clarke & Verdier: 64, pl. 1, figs. 9, 10, text-fig. 26.

Description. The shell is spherical to ovoidal and possesses a well developed tabulation. The shell surface is either lightly or coarsely granular. The two plates observed by Sarjeant in the medial region of the sulcus are not always delimited. The sutural crests are often relatively high and give rise to numerous, well developed thorn-like spines (Fig. 13H).

Dimensions. Range of type material: shell length 25 (29·3) 37 μ, width 21 (26·2) 31 μ, maximum height of crests 1·5 (3·8) 7 μ. Number of specimens measured, 22.

Remarks. In general form *M. setosum* is similar to *M. ornatum* but differs in the presence of spiny crests, a dense granulation and, slightly, in the tabulation exhibited.

Occurrence. *M. setosum* is an infrequent to fairly common species at most horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has also been recorded from the Albian of Fetcham Mill.

Microdinium distinctum sp. nov.

(Pl. 2, figs. 9–11; Figs. 13D, E. I)

1967 *Microdinium ornatum* Cookson & Eisenack; Clarke & Verdier: pl. 5, figs. 11–12.

Derivation of name. Latin, *distinctus*, different—with reference to the distinctive appearance of this species.

Diagnosis. Shell subspherical, thick-walled, smooth. Sutural crests well developed bearing short, broad, flat-topped spines. Reflected tabulation 1, 0a, 6″ 6‴, 1p, 1⁗; plates 1″ and 6″ very reduced and cingular plates absent. Cingulum broad, weakly laevo-rotatory.

Holotype. G.S.M., slide PF 3989, (1). Lower Chalk, H.M. Geological Survey Borehole, Fetcham Mill, Surrey at 730 ft. depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: shell length 36 μ, width 37 μ, height of crests *c.* 2 μ. Range: shell length 29–36 μ, width 30–37 μ, height of crests 2–2·5 μ. Number of specimens measured, 7.

Description. The shell wall is relatively thick, *c.* 1 μ, and develops pronounced ridges at the plate boundaries. The sutural spines are closely set, very broad and flat distally.

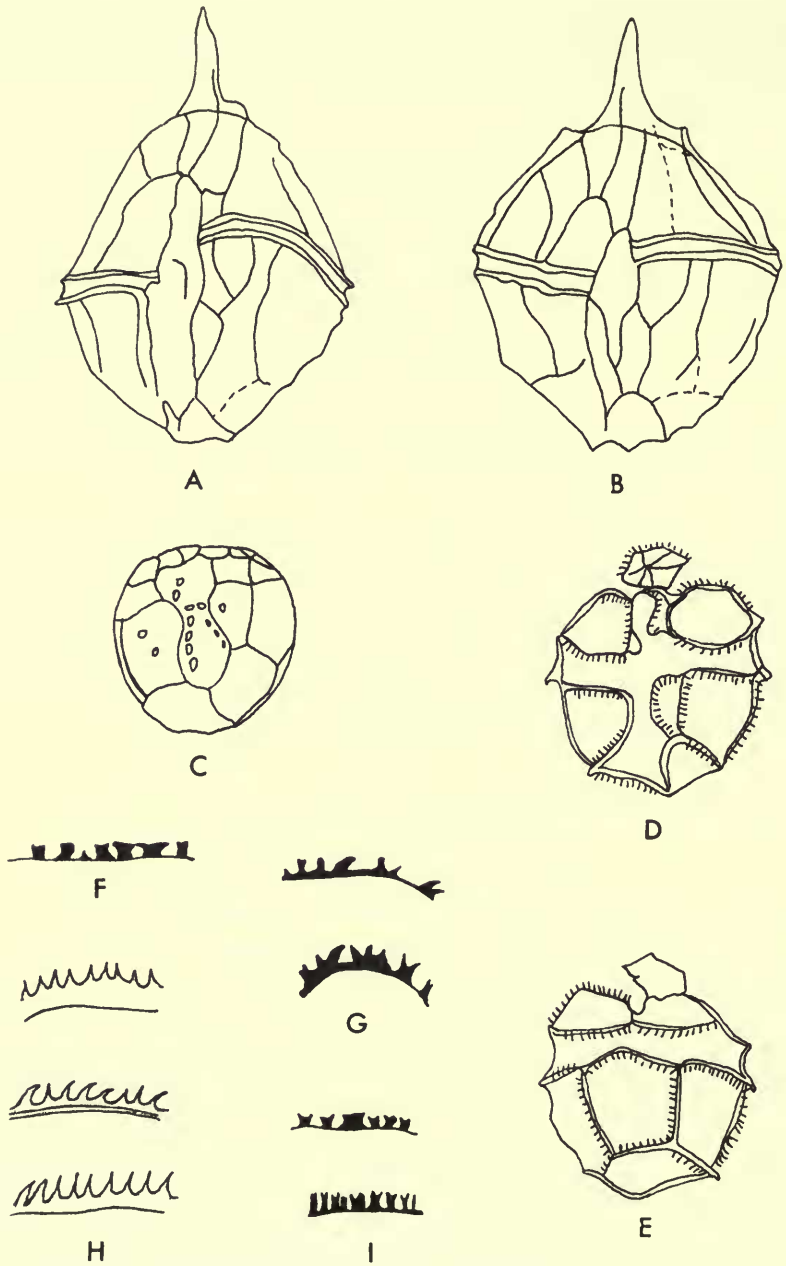

FIG. 13. *Cribroperidinium orthoceras* (Eisenack). A. Specimen illustrated by Eisenack (1958, text-fig. 3) redrawn to show full crestal arrangement. B. Holotype (Eisenack 1958, text-fig. 2) redrawn to show full crestal arrangement. *Microdinium* cf. *ornatum* Cookson & Eisenack, C. Ventral surface of Holotype (× 700). *Microdinium distinctum* sp. nov., D. Ventral surface of Holotype (× 700), E. Dorsal surface of Holotype (× 700). *Microdinium* cf. *ornatum* Cookson & Eisenack, F. Sutural spines. *Microdinium variospinum* sp. nov., G. Sutural spines. *Microdinium setosum* Sarjeant, H. Sutural spines. *Microdinium distinctum* sp. nov., I. Sutural spines.

The precingular plates are generally smaller than the postcingular plates. Plates 1″ and 6″ are small and appear as slight projections in the ventral area. This is widest posteriorly and is open anteriorly. The apical plate is six-sided and is lost in archaeopyle formation. The archaeopyle possesses slits extending posteriorly between the precingular plates.

Remarks. *M. distinctum* may be distinguished from all other species of *Microdinium* by the thick, smooth shell wall, the form of the precingular plates and the absence of cingular plates. It is considered that the absence of the latter does not, at present, warrant the erection of a new genus.

Occurrence. This species is very rare, being recorded only seven times, from the following samples: FM 790, FM 730, FM 710, FM 690, E 153 and CB 17. It has never been observed in the lower horizons of the Cenomanian.

Microdinium variospinum sp. nov.

(Pl. 2, figs. 5, 6; Fig. 13G)

Derivation of name. Latin, *varius*, different; *spinosus*, spine—with reference to the variable appearance of the spines.

Diagnosis. Shell subspherical to ovoidal; shell wall thin, smooth, granular or lightly reticulate. Sutural crests low, bearing small number of variably shaped spines. These may be simple tubercles to complex bifurcating protrusions. Reflected tabulation 1′, 0a, 6″, (6c), 6‴, 1p, 1⁗; cingular plate boundaries very faint or absent. Cingulum weakly laevo-rotatory.

Holotype. B.M. (N.H.) V. 51981 (1). Lower Chalk, Bureau de Recherches Géologiques et Minières Borehole, Escalles, Pas de Calais at 165 metres depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: shell length 24 μ, width 23 μ, length of spines 1–1·5 μ Range: shell length 20 (23·6) 27 μ, width 17 (20·0) 23 μ, length of spines 1–3 μ. Number of specimens measured, 9.

Description. The cingular plate boundaries are usually absent, however, one Saskatchewan specimen had them lightly defined. The sutural spines are few in number and tend to be concentrated at the posterior of the shell (Pl. 2, fig. 5). They are stout and may be either pointed or flattened distally (Fig. 13G).

Remarks. The characteristic features of *M. variospinum* are the nature of the shell wall, the form of the spines and the lack of well defined cingular plate boundaries. These characters together differentiate this species from all other described species.

Occurrence. *M. variospinum* is a rare species found at all horizons, save the lower three, at Escalles, and in sample CB 1, CB 7 and Sas 1084. It has not been recorded from Fetcham Mill.

Microdinium veligerum (Deflandre) comb. nov.

(Pl. 3, fig. 4; Pl. 4, fig. 4)

1937 *Micrhystridium veligerum* Deflandre : 81, pl. 12, fig. 9.
1943 *Ceratocorys veligera* (Deflandre) Lejeune–Carpentier : 22, text-figs. 1–6.
1952*a* *Ceratocorys veligera* (Deflandre) Deflandre : 120, text-fig. 102.
1952b *Ceratocorys veligera* (Deflandre) Deflandre: text-figs. 304 A–C.
1967 *Eisenackia crassitabulata* Deflandre & Cookson; Clarke & Verdier: 64, pl. 8, figs. 4–6.

Description. The shell is ovoidal, densely granular and bears a number of high crests delimiting a tabulation. The crests are distinctive, being 1 to 5 μ in height, with typically a smooth outer margin. They consist of two membranes, joined distally and diverging proximally to form a broad base, 1 to 3 μ, wide to the crest. There is between the two membranes a crestal cavity which is occasionally subdivided by septa, particularly where two crests diverge. Here a conical chamber is usually found. The reflected tabulation appears to be 1′, ?5″, 6c, 6‴, 1p, 1⁗. The hypotract is considerably larger than the epitract, the latter being devoid of crests and usually possessing a pentagonal apical archaeopyle. The shape of the latter is the only indication that there are five precingular plates. The cingulum is broad and does not appear to be spiral. Plate 1‴, and to a lesser extent 2‴, are reduced to accommodate the posterior intercalary plate. The remaining four postcingular plates are large and there is a single large antapical plate. The sulcus is very narrow just posterior to the cingulum and then widens rapidly towards the antapex. The sulcus extends onto the epitract where it sometimes bears five small sulcal plates.

Dimensions. Range of observed specimens: shell length 28 (31·5) 38 μ, width 25 (28·2) 32 μ. Number of specimens measured, 13.

Remarks. Lejeune-Carpentier (1943) placed this species, originally observed in the Upper Cretaceous of France, in the genus *Ceratocorys* Stein (1883) on the basis of its similarity to motile dinoflagellates contained in this genus. However, it is a cyst possessing an apical archaeopyle and should not be attributed to a motile dinoflagellate genus. Thus this species is here transferred to *Microdinium* on the basis of the tabulation, apical archaeopyle, reduced size of epitract compared with the hypotract and overall small size. *M. veligerum* does, however, differ slightly from the other species in this genus by the apparent absence of crests on the epitract and the probable presence of five precingular plates instead of six.

Eisenackia crassitabulata as illustrated by Clarke & Verdier (1967) is undoubtedly *M. veligerum*. The former, as originally described from the Australian Lower Tertiary, is of different overall form and is considerably larger (72–78 by 55–67 μ). The size of the specimen illustrated by Clarke & Verdier is approximately 30 by 32 μ and is thus comparable to the Cenomanian specimens of *M. veligerum*. *E. crassitabulata* has been recorded from the Lower Tertiary and also from the Maestrichtian of South Africa by the present author. *M. irregulare* Clarke & Verdier (1967) appears to be very similar to *M. veligerum* and any definite distinction is not apparent.

Occurrence. The Cenomanian forms examined resemble the specimens illustrated by Lejeune-Carpentier in all respects. *M. veligerum* is an infrequent to

common species at all horizons, save two, at Fetcham Mill, Compton Bay and Escalles. These two horizons are basal Cenomanian, FM 840 and CB 1, and it was not recorded by Cookson & Hughes (1964) from the Upper Albian/basal Cenomanian of Cambridgeshire. It is also absent in the North American material and has not been described from Australia. This species is present in sample FM 520 of Turonian age. *M. veligerum* thus appears for the first time just above the base of the Cenomanian and extends into the Turonian but is, apparently, of restricted geographical distribution.

?Microdinium crinitum sp. nov.

(Pl. 2, figs. 7, 8)

1967 *Cometodinium obscurum* Deflandre & Courteville; Clarke & Verdier: pl. 10, fig. 3: pl. 11, fig. 9.

Derivation of name. Latin, *crinitus*, hairy—with reference to the numerous hair-like spines.

Diagnosis. Shell subspherical, periphragm granular and giving rise to numerous, fine, flexuous spines. Sutural crests low, bearing numerous spines. Cingulum wide, composed of elongate plates. Epitract smaller than hypotract. Archaeopyle not normally visible.

Holotype. G.S.M. slide PF 3990(1). Lower Chalk, H.M. Geological Survey Borehole, Fetcham Mill, Surrey at 690 feet depth. Upper Cretaceous (Cenomanian.)

Dimensions. Holotype: shell diameter 27 by 28 μ, length of spines *c.* 12 μ. Range: shell diameter 24 (30·1) 38 μ, length of spines 6–19 μ. Number of specimens measured, 18.

Description. The periphragm granules, which are evenly spaced on the shell surface, are up to 0·5 μ high, and often form the bases of the hair-like spines. The latter tend to be especially concentrated along the sutures, and because of this tendency and the spherical form of the shell, it has not been possible to fully formulate a tabulation. However, precingular, cingular and postcingular plates are quite obvious when the orientation is favourable, the precingular plates being smaller than the postcingular plates. The cingulum is broad, *c.* 5 μ. The archaeopyle, although it has not been observed, is probably apical.

Remarks. The numerous hair-like spines and the tabulation easily distinguish ?*M. crinitum* sp. nov. from all previously described forms of dinoflagellate cysts. The overall shape, the small size and the fact that the epitract is smaller than the hypotract all indicate that this species is closely related to the genus *Microdinium*. However, plate spines have not been recorded in *Microdinium*, although a granulation has, and since the tabulation has not been elucidated in the present species it is only placed tentatively in this genus.

Occurrence. ?*M. crinitum* is infrequent at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles and is also present in the Albian sample from Fetcham Mill, sample FM 886. It has only once been recorded at Saskatchewan, in sample Sas 835 (Cenomanian).

Genus *HISTIOCYSTA* nov.

Derivation of name. Greek, *histos*, mesh or network; *kystis*, sac or cell—with reference to the reticulate ornamentation on the shell surface.

Diagnosis. Proximate cysts, spherical to subspherical; shell wall composed of two layers; outer layer giving rise to low crests. Crests reflecting *Gonyaulax*—type tabulation and coarse, subsidiary reticulation within plate boundaries. Sutural crests better defined than crests of subsidiary reticulation. Archaeopyle apical with angular margin. Operculum probably single apical plate.

Type species. *Histiocysta palla* sp. nov. Lower Chalk (Cenomanian); England.

Remarks. The reasonably well defined tabulation, the plate ornamentation and the apical archaeopyle easily distinguish *Histiocysta* from all previously described genera. The most similar genera are *Ellipsoidictyum* Klement (1960*b*) and *Dictyopyxidia* Eisenack (1961), both from the Upper Jurassic. Both genera possess an apical archaeopyle and a cingulum but a distinct *Gonyaulax*-type tabulation is absent. However, it seems probable that *Histiocysta* is genetically related to these two genera. Although the precise tabulation of *Histiocysta* cannot be elucidated the presence of precingular, cingular and postcingular series of plates together with an apical archaeopyle indicate that this genus belongs to the Family Microdiniaceae.

Histiocysta palla sp. nov.

(Pl. 1, figs. 5, 6; Figs. 14A, B)

1939 *Micrhystridium* sp.? Deflandre & Courteville : pl. 3, fig. 4.

Derivation of name. Greek, *palla*, ball—with reference to the more or less spherical shape of this species.

Diagnosis. Shell spherical to subspherical, thin-walled, periphragm smooth and forming a reticulate network of crests. Network consisting of reflected dinoflagellate tabulation with central region of each plate occupied by coarse but simple reticulation.

Holotype. G.S.M. slide PF 3052 (2). Lower Chalk, H.M. Geological Survey Borehole, Fetcham Mill, Surrey at 650 feet depth. Upper Cretaceous (Cenomanian).

Paratype. G.S.M. slide PF 3991(1). Lower Chalk, H.M. Geological Survey Borehole, Fetcham Mill, Surrey at 710 feet depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: shell diameter 30 by 33 μ, height of crests 4–5 μ. Paratype: shell diameter 26 by 29 μ, height of crests *c.* 2·5 μ. Range: shell diameter 25 (31·8) 38 μ, height of crests 1–5 μ. Number of specimens measured, 19.

Description. The precingular and postcingular plates may be observed on most specimens but the exact tabulation has not, as yet, been elucidated. The central region of each plate is occupied by a coarse, subpolygonal reticulation which occasionally extends to the plate boundaries (Figs. 14A, B). The cingular region is clearly defined by crests and encircles the shell. Cingular plates are not usually discernible,

the entire region being occupied by a coarse reticulation. An apical archaeopyle with an angular margin is typically present, the six-sided operculum often remaining attached to the shell.

Remarks. The combination of apical archaeopyle, tabulation and reticulation makes *H. palla* an easily recognizable species distinct from all previously described

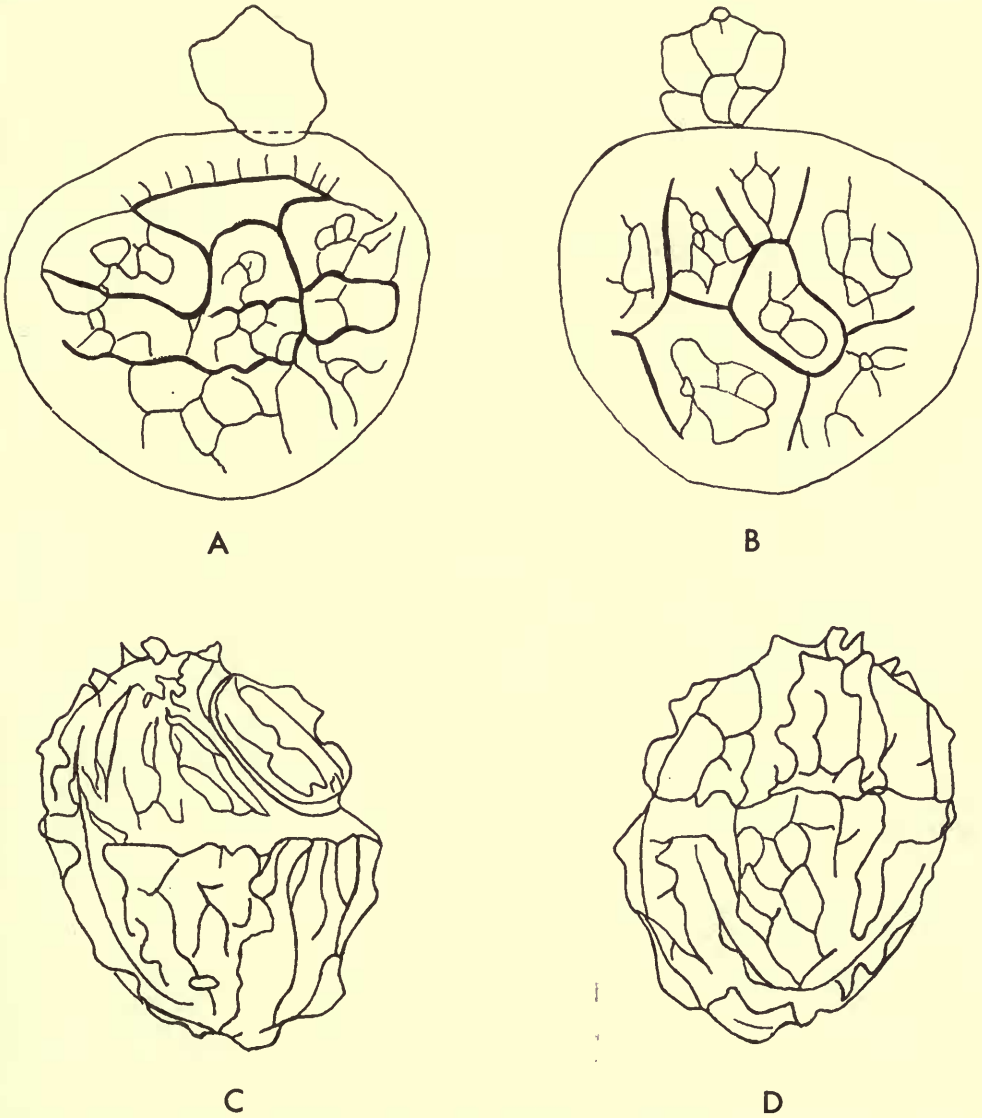

Fig. 14. *Histiocysta palla* sp. nov., A. Lateral view of Holotype showing attached operculum, apical archaeopyle, precingular plates and cingulum (× 1300). B. Lateral view of Holotype showing well defined plate boundaries (× 1300). *Ellipsodinium rugulosum* Clarke & Verdier, C. Lateral view showing partially detached operculum and cingulum (× 1300). D. Lateral view (× 1300).

forms. This species was figured, but not described, by Deflandre & Courteville (1939) as *Micrhystridium* sp.? from the Senonian. *Membranilarnax* cf. *pterospermoides* Deflandre (1937) is of similar form but does not possess a reticulation.

Occurrence. *H. palla* is found throughout the European Cenomanian, except for the lowermost horizons. It is fairly common at Fetcham Mill but rare at Compton Bay and Escalles. It has not been observed in the North American samples.

Cyst-Family **FROMEACEAE** Sarjeant & Downie 1966

Genus ***FROMEA*** Cookson & Eisenack 1958

Remarks. A number of specimens referable to the type species, *F. amphora*, do not appear to possess a cingulum. The absence of a cingulum makes this genus similar to *Chytroeisphaeridia* Sarjeant (1962). They differ, however, in that the archaeopyle of *Fromea* has a rounded margin, and in the elongate shape typical of the latter genus.

Fromea amphora Cookson & Eisenack

(Pl. 3, figs. 2, 3)

1958 *Fromea amphora* Cookson & Eisenack : 56, pl. 5, figs. 10, 11.
1966*b* *Fromea amphora* Cookson & Eisenack; Sarjeant : 209, pl. 22, fig. 4; pl. 23, fig. 3 (see also for earlier references).

Description. The shell is ovoidal, thick-walled (2–3 μ) and typically possesses an apical archaeopyle with a rounded margin. In one specimen (Pl. 3, fig. 3) the apical region is still attached and may be seen to be perfectly rounded. A cingulum was not observed in any of the specimens.

Dimensions. Range of observed specimens: shell length 56 (72·5) 85 μ, width 47 (60) 71 μ. Number of specimens measured, 6.

Remarks. The Cenomanian specimens are identical with the type material from the Aptian-Cenomanian of Australia except that the cingulum is absent. Cookson & Eisenack (1958) state, however, that the cingulum may be rather faint and it is probable that the European forms fall within the range of variation for this species. *F. amphora* has been recorded from the Barremian of England by Sarjeant (1966*b*). The specimens described by Sarjeant, like the Cenomanian forms, do not possess a cingulum. Maliavkina *et al.* (1961) describes some very similar, but rather smaller, forms from the Maestrichtian of Siberia, calling them *Chrysomonadinae*?. These forms possess the typical rounded archaeopyle of this genus.

Occurrence. Five specimens have been recorded from Fetcham Mill, from samples FM 810, 770, 750 and 650, and one specimen from Escalles, sample E 177.

Genus ***CHYTROEISPHAERIDIA*** Sarjeant 1962

Remarks. *Chytroeisphaeridia* and *Cannin*gia Cookson & Eisenack (1960*b*) are similar and probably fairly closely related. The latter is usually more polygonal, has an apical horn, and sometimes the vestiges of a cingulum.

Chytroeisphaeridia euteiches sp. nov.

(Pl. 3, figs. 8, 9)

Derivation of name. Greek, *euteiches*, well-walled—with reference to the stout wall of this species.

Diagnosis. Shell subspherical; shell wall thick and densely granular. Angular apical archaeopyle typically present.

Holotype. B.M. (N.H.) V. 51982 (2). Lower Chalk, Bureau de Recherches Géologiques et Minières Borehole, Escalles, Pas de Calais, at 159 metres depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: shell length 53 μ, width 59 μ. Range: shell length 48–60 μ, width 49–59 μ. Number of specimens measured, 6.

Description. The shell wall is thick (2–3 μ) and may be composed of two layers. If the wall is bipartite then the inner layer is thin, the outer layer making up almost the entire wall thickness. This layer appears to be composed of minute cellular elements and is densely granular on the surface. The apical archaeopyle, when developed, is angular with small slits passing posteriorly from its margin between each precingular plate. A sulcal notch is also present (Pl. 3, fig. 8). Plate boundaries and cingulum are not discernible.

Remarks. This species is a simple, subspherical shell possessing an apical archaeopyle. One species, *C. chytroeides* Sarjeant (1962), from the Upper Jurassic of England, differs from C. *euteiches* in having a fairly thin and only slightly granular shell wall. *Chytroeisphaeridia* sp. Sarjeant (1965*b*) is similar in size and also granular but does not possess a thick shell wall. *Canningia rotundata* Cookson & Eisenack (1961) is also similar but tends to have a polygonal shell with a small apical horn.

Occurrence. *C. euteiches* has been recorded from two horizons only, E 165, & E 159 from Escalles, where it is infrequent.

Genus ***CASSICULOSPHAERIDIA*** nov.

Derivation of name. Latin, *cassiculus*, hunting-net; *sphaera*, ball—with reference to the surface reticulation of the shell.

Diagnosis. Proximate cysts; shell spherical to subspherical, composed of two layers, without apical or antapical protuberances. Periphragm giving rise to low crests or membranes which form a reticulate pattern. Tabulation absent. Archaeopyle apical with angular margin.

Type Species. *Cassiculosphaeridia reticulata* sp. nov. Lower Chalk (Cenomanian); France.

Remarks. The surface reticulation of this genus is very similar to that of *Ellipsoidictyum cinctum* Klement (1960). Both possess an apical archaeopyle, but whereas in *Cassiculosphaeridia* all signs of a tabulation are absent, in *Ellipsoidictyum* there is an obvious cingulum. *Dictyopyxidia* Eisenack (1961) is also very similar but possesses a cingulum and sulcus.

Cassiculosphaeridia reticulata sp. nov.

(Pl. 3, fig. 7; Pl. 4, fig. 3)

Derivation of name. Latin, *reticulatus*, net-like—with reference to the reticulate pattern formed by the periphragm crests.

Diagnosis. Shell spherical to subspherical. Shell surface bearing low ridges, forming a coarse reticulation, from which arise fine membranous crests. Shell wall lightly to densely granular.

Holotype. B.M. (N.H.) V.51981 (4). Lower Chalk, Bureau de Recherches Géologiques et Minières Borehole, Escalles, Pas de Calais, at 165 metres depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: shell diameter 38 by 38 μ, height of crests 4 to 6 μ. Range: shell diameter 33 (43·6) 55 μ, maximum height of crests 3 (7·3) 11 μ. Number of specimens measured, 15.

Description. The areas delimited by the low ridges are typically subpolygonal but may be of irregular shape. They vary considerably in size, from 2 to 10 μ in diameter. The membranous crests are very fine and tend to be flexuous since supporting structures are absent.

Remarks. The surface reticulation, the absence of any tabulation and the apical archaeopyle together distinguished this species from all previously described forms.

Occurrence. *C. reticulata* is rare to common in samples from the Middle and Upper Cenomanian of Fetcham Mill (not found below sample FM 750), and from the Lower, Middle and Upper Cenomanian of Escalles (not found below sample E 207). This species was absent from the samples from Compton Bay and from North America.

Genus ***EPELIDOSPHAERIDIA*** nov.

Derivation of name. Greek, *epelidos*, cover or lid; *sphaera*, ball—with reference to the conical apical operculum which sometimes remains attached to the shell.

Diagnosis. Shell subpolygonal; epitract conical with small apical protuberance, hypotract polygonal with small antapical horn on one side. Shell wall two layered, periphragm giving rise to a moderate number of spines, truncated or forked distally Cingulum and sulcus outlined by spines. Cingulum slightly laevo-rotatory. Apical archaeopyle.

Type species. *Palaeoperidinium spinosum* Cookson & Hughes 1964. Cambridge Greensand (Cenomanian), England.

Remarks. The presence of an apical archaeopyle, together with a well developed cingulum and sulcus differentiate *Epelidosphaeridia* from all previously described genera. *Doidyx* Sarjeant (1966*b*) is most similar but differs in that the shell is asymmetrical, the hypotract is conical and a sulcus is absent.

Epelidosphaeridia spinosa (Cookson & Hughes) comb. nov.

(Pl. 3, figs. 10–12)

1964 *Palaeoperidinium spinosum* Cookson & Hughes : 49, pl. 8, figs. 6–8.
1967 *Palaeoperidinium spinosum* Cookson & Hughes: Clarke & Verdier: 70, pl. 14, figs. 10–12.

Description. The shell possesses convex sides, conical epitract and a hypotract which is more or less truncated posteriorly. A small apical prominence is commonly present. The periphragm is smooth or lightly granular and forms a moderate number of small, stout spines. The spines appear to be hollow, closed proximally, parallel sided, and are oblate distally or terminate with a small fork. The spines widen slightly before joining the shell and they are sometimes joined proximally. This is particularly well developed in the antapical region where the processes are joined medially and form a slight projection on one side of the shell. The cingulum is clearly delimited by two parallel lines of closely set spines and is 5 to 8 μ in width. It is only slightly helicoid and bears few spines on its surface. The sulcus in most specimens is clearly defined, being slightly hollowed and almost devoid of spines. The spines on the remainder of the shell surface are usually randomly arranged, but occasionally a vague alignment is present suggesting a tabulation. An apical archaeopyle is constantly developed, the margin being only slightly angular.

Dimensions. Range of observed specimens: shell length 32 (43) 56 μ, width 27 (42·1) 57 μ, maximum length of spines 2·5 (3·7) 5 μ. Number of specimens measured, 21.

Remarks. The Cenomanian specimens examined strongly resemble the type material from the Cambridge Greensand and Chalk Marl (Lower Cenomanian) of Cambridgeshire, England. In the lower horizons of the Cenomanian the sulcus, although always present, is not so clearly defined as in higher horizons.

Occurrence. *E. spinosa* is a rare to common species in the lower and middle horizons of the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It is absent from samples FM 690, 670, 650; CB 13, 15, 17, 19, 21; and E 159, 153. It has only beeen observed in one North American sample—sample Sas 1023 (Saskatchewan, Albian).

Cyst-Family **HYSTRICHOSPHAERIDIACEAE** Evit emend.
Sarjeant & Downie 1966

Genus ***HYSTRICHOSPHAERIDIUM*** Deflandre emend. Davey & Williams 1966

Hystrichosphaeridium tubiferum (Ehrenberg)

(Pl. 5, figs. 5, 8)

1838 *Xanthidium tubiferum* Ehrenberg : pl. 1, fig. 16.
1966*b* *Hystrichosphaeridium tubiferum* (Ehr.) Davey & Williams : 56, pl. 6, figs. 1, 2; pl. 8, fig. 5; pl. 10, fig. 2; text-fig. 13. (See also for earlier references).

Dimensions. Range of observed specimens: diameter of central body 28 (38·1) 51 μ, maximum length of processes 15 (25·0) 37 μ. Number of specimens measured, 26.

Remarks. *H. tubiferum* is an infrequent to common species at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It is also recorded from the Albian (sample FM 886) and Turonian (sample FM 520) of Fetcham Mill. This species was not recorded in the North American material. Thus the earliest recording of *H. tubiferum* is from the Albian; it ranges throughout the Upper Cretaceous and has been recorded from the Eocene (Ypresian) by Davey & Williams (1966*b*). It is a long-ranging species of little stratigraphic value.

Hystrichosphaeridium deanei Davey & Williams

(Pl. 4, fig. 1)

1966*b* *Hystrichosphaeridium deanei* Davey & Williams : 58, pl. 6, figs. 4, 8.
1967 *Hystrichosphaeridium stellatum* Maier; Clarke & Verdier: 55, pl. 12, figs. 1, 2.

Dimensions. Range of observed specimens: diameter of central body 37 (45·7) 54 μ, maximum length of processes 22 (35·8) 45 μ. Number of specimens measured, 10.

Remarks. One specimen, occurring in sample E 207 (Escalles), possesses broad processes and appears to occupy a position midway between *H. deanei* and *H. tubiferum*.

Occurrence. *H. deanei* is a rare species confined to the Middle and Upper Cenomanian of Fetcham Mill, Compton Bay and Escalles (Table 25). The samples in which it first occurs are FM 710 (Fetcham Mill), CB 13 (Compton Bay) and E 195 (Escalles). *H. deanei* has also been recorded from the Turonian sample FM 520, from Fetcham Mill. It is absent from the North American material.

Hystrichosphaeridium readei Davey & Williams

1966*b* *Hystrichosphaeridium readei* Davey & Williams : 64, pl. 6, fig. 3 (See also for earlier references).

Dimensions. Range of observed specimens: diameter of central body 31 (42·1) 57 μ, maximum length of processes 23 (29·7) 35 μ. Number of specimens measured, 11.

Occurrence. *H. readei* is very rare in samples FM 810, 790, 770 (Fetcham Mill) and E 207 (Escalles); and it is rare to infrequent in samples FM 690, 670, E 183, 177, 165, 159 and CB 9 (Compton Bay). Two specimens were recorded in the Albian sample (FM 886) from Fetcham Mill. This species was not recorded in the North American samples.

Hystrichosphaeridium radiculatum Davey & Williams

(Pl. 4, fig. 8)

1966*b* *Hystrichosphaeridium radiculatum* Davey & Williams : 65, pl. 7, fig. 9; pl. 9, fig. 6.

Dimensions. Range of observed specimens: diameter of central body 27 (38·8) 43 μ, maximum length of processes 12 (15·9) 20 μ. Number of specimens measured, 11.

Occurrence. *H. radiculatum* is a very rare to infrequent species occurring at a number of horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has also been recorded in the Albian sample from Fetcham Mill (sample FM 886), but is absent from the North American material.

Hystrichosphaeridium mantelli Davey & Williams

(Pl. 4, fig. 9)

1966*b* *Hystrichosphaeridium mantelli* Davey & Williams : 66, pl. 6, fig. 6.

Dimensions. Range of observed specimens: diameter of central body 32 (38·6) 48 μ, maximum length of processes 12 (21·4) 26 μ. Number of specimens measured, 15.

Remarks. The reticulate nature of the central body and the fibrous processes differentiate *H. mantelli* from most previously described species. *H. radiculatum* is the most similar but differs from *H. mantelli* by the more branched and deeply furcate processes and the tendency for the fibrils of the processes to continue across the surface of the central body.

Occurrence. *H. mantelli* is a very rare to infrequent species occurring in most samples throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has also been recorded in the Turonian sample from Fetcham Mill (sample FM 520), but is absent from the North American material.

Hystrichosphaeridium bowerbanki Davey & Williams

(Pl. 5, fig. 9)

1966*b* *Hystrichosphaeridium bowerbanki* Davey & Williams : 69, pl. 8, figs. 1, 4.

Dimensions. Range of observed specimens: diameter of central body 25 (31·9) 40 μ, maximum length of processes 20 (25·5) 28 μ. Number of specimens measured, 10.

Remarks. *H. bowerbanki* is rare to infrequent in six Middle Cenomanian samples—FM 770, 750, 730 and 690 from Fetcham Mill and CB 9, and 17 from Compton Bay. It has also been recorded from the Albian sample (FM 886) and the Turonian sample (FM 520), both from Fetcham Mill.

Hystrichosphaeridium difficile Manum & Cookson

(Pl. 4, figs. 2, 6, 7)

1964 *Hystrichosphaeridium difficile* Manum & Cookson : 12, pl. 3, figs. 1–3, 7.

Description. The shell is subspherical, sometimes with a small apical prominence; shell wall thick (*c.* 1 μ), smooth to lightly granular. The processes, approximately 30 in number, are complex, usually broadly tubiform or buccinate in shape, of constant length on any specimen but variable in width (3 to 18 μ). Distally the

larger processes have a rectangular opening, with a serrate margin which gives rise to four broad spines. Typically there are four bands of thickening extending along the length of the processes and passing onto the shell surface. There, each joins with a similar thickening from a neighbouring process, thus forming a coarse reticulation on the shell surface. The large tubular processes are arranged in a circular manner around the shell, reflecting the precingular, cingular and postcingular series of plates. Fine processes are uncommon and may be sulcal in position. An apical archaeopyle is typically developed and possesses an angular margin marked at intervals with V-shaped notches. Although often remaining attached, isolated operculae have been identified (Pl. 4, figs. 6, 7) and bear four moderate-sized tubular processes.

Dimensions. Range of observed specimens: diameter of central body 49 (64·9) 79 μ, maximum length of processes 18 (24·5) 31 μ. Number of specimens measured, 8.

Remarks. The specimens studied are extremely similar to the type material of Lower Cretaceous age described by Manum & Cookson (1964) from Arctic Canada. The only difference appears to be that in the type material the shell surface has a fine reticulation which is absent from the specimens studied.

Two similar species are *H. costatum* Davey & Williams (1966*b*) from the Oxford Clay of England and *H. readei* Davey & Williams (1966*b*) from the Cenomanian of England. However, both species are considerably smaller than *H. difficile* and possess narrower and less complex processes.

Occurrence. *H. difficile* has only been recorded from the Saskatchewan material. It is infrequent in samples Sas 1084 (Albian) and Sas 890 (Cenomanian), and common in sample Sas 805 (Cenomanian).

Genus ***OLIGOSPHAERIDIUM*** Davey & Williams 1966

Oligosphaeridium complex (White)

(Pl. 5, figs. 6, 7)

1842 *Xanthidium tubiferum complex* White : 39, pl. 4, div. 3, fig. 11.
1966*b* *Oligosphaeridium complex* (White) Davey & Williams : 71, pl. 7, figs. 1, 2; pl. 10, fig. 3; text-fig. 14 (See also for earlier references).
1967 *Hystrichosphaeridium complex* (White) Clarke & Verdier: 53, pl. 11, figs. 10, 11.

Dimensions. Range of observed specimens: diameter of central body 34 (41·1) 55 μ, maximum length of processes 22 (34·6) 43 μ. Number of specimens measured, 12.

Remarks. Davey & Williams described examples of *O. complex* from the Speeton Clay (Barremian), Lower Chalk (Cenomanian) and London Clay (Ypresian), all from England.

Occurrence. *O. complex* is a rare to common species in all samples from Fetcham Mill, Compton Bay and Escalles. It is also present in the Albian sample (FM 886) and the Turonian sample (FM 520) both from Fetcham Mill. This species is present

in the Albian and the lowermost Cenomanian sample from Saskatchewan—Sas 1084 1023, 967, and 890—but is absent from the Texas samples.

O. complex thus has a known stratigraphic range from the Neocomian (Gocht 1959; Cookson & Eisenack 1958) to the Eocene, Ypresian (Davey & Williams 1966*b*).

Oligosphaeridium reticulatum Davey & Williams

1966*b* *Oligosphaeridium reticulatum* Davey & Williams : 74, pl. 7, fig. 10.

Dimensions. Range of observed specimens: diameter of central body 29–47 μ, length of processes 14–26 μ. Number of specimens measured, 5.

Occurrence. *O. reticulatum* is an infrequent species occurring in the two lower samples from Fetcham Mill, samples FM 840 and 810.

Oligosphaeridium prolixispinosum Davey & Williams

(Pl. 5, fig. 4)

1966*b* *Oligosphaeridium prolixispinosum* Davey & Williams : 76, pl. 8, figs. 2, 3.

Dimensions. Range of observed specimens: length of central body 33 (39·0) 43 μ, width 20 (28·7) 34 μ, maximum length of processes 18 (25·0) 30 μ. Number of specimens measured, 15.

Occurrence. *O. prolixispinosum* is a rare species confined mainly to the Lower and Middle Cenomanian of Fetcham Mill and Escalles, although it does occur occasionally in the Upper Cenomanian. This species has only been recorded twice in the samples CB 17 and 21 from Compton Bay, both from the Upper Cenomanian. It has not been recorded in the North American material.

Oligosphaeridium anthophorum (Cookson & Eisenack)

(Pl. 5, figs. 1, 2, 3)

1958 *Hystrichosphaeridium anthophorum* Cookson & Eisenack : 43, pl. 11, figs. 12, 13; text-figs. 16–18.
1958 *Hystrichosphaeridium anthophorum* Cookson & Eisenack; Eisenack, 402, pl. 26, figs. 1, 2.
1961 *Hystrichosphaeridium anthophorum* Cookson & Eisenack; Alberti : 34, pl. 9, fig. 16.
1966*b* *Oligosphaeridium anthophorum* (Cookson & Eisenack) Davey & Williams : 77.

Description. The shell is subspherical; shell wall smooth to lightly granular. An apical archaeopyle is typically developed and possesses an angular margin. The processes are hollow, buccinate to infundibular, with the distal flared portion perforate. Distally the margins of the processes are usually entire, but may bear one or two small spines. A complete specimen possesses 18 processes, reflecting a tabulation characteristic of this genus. The processes are all of equal size except for the first postcingular (1‴) and the posterior intercalary (1p) which are often reduced.

Dimensions. Range of observed specimens: diameter of central body 38 (46·3) 57 μ, maximum length of processes 18 (34·1) 43 μ. Number of specimens measured, 8.

Remarks. The presence of complex perforate processes having an entire distal margin differentiate this species from all other similar forms.

Occurrence. *O. anthophorum* has been recorded from the Upper Jurassic—Lower Cretaceous (Aptian–Albian) of Australia (Cookson & Eisenack 1958), from the Aptian of Germany (Eisenack 1958) and from the Upper Barremian—Albian of Germany (Alberti 1961). This species has been recorded from one sample, Sas 1023, from the Albian of Saskatchewan where it is common.

Oligosphaeridium reniforme (Tasch)

(Pl. 6, fig. 1)

1964 *Hystrichosphaeridium reniforme* Tasch : 193, pl. 2, fig. 6.
1966*b* *Oligosphaeridium reniforme* (Tasch) Davey & Williams : 77.

Description. The shell is subspherical to ovoidal, shell wall lightly granular. The processes are hollow, tubiform, widening distally into a broad, flat-topped funnel. The distal margin of the funnel bears a small number of pointed and irregularly shaped spines. Distally the processes sometimes possess large, subcircular perforations. An apical archaeopyle is typically developed.

Dimensions. Range of observed specimens: diameter of central body 31 (42·4) 49 μ, maximum length of processes 20 (24·9) 30 μ. Number of specimens measured, 7.

Remarks. The specimens appear to be very similar to the type material from the Albian of Kansas although Tasch did not describe the presence of distal perforations. *O. reniforme* differs from *O. anthophorum* and *O. perforatum* (Gocht 1959) by the presence of distal spines. It differs from *O. pulcherrimum* Deflandre & Cookson (1955) in that the processes possess only a few spines, are not so complexly perforate and distally are flat-topped.

Occurrence. *O. reniforme* is infrequent in all the Albian–Cenomanian samples from Saskatchewan. It has not been recorded elsewhere.

Genus ***LITOSPHAERIDIUM*** Davey & Williams 1966

Litosphaeridium siphoniphorum (Cookson & Eisenack)

(Pl. 6, figs. 3, 4; Fig. 15)

1958 *Hystrichosphaeridium siphoniphorum* Cookson & Eisenack : 44, pl. 11, figs. 8–10.
1966*b* *Litosphaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams : 80, pl. 7, figs. 7, 8; text-figs. 16, 17. (See also for earlier references).
1967 *Hystrichosphaeridium siphoniphorum* Cookson & Eisenack; Clarke & Verdier: 55, pl. 11, figs. 1, 2.

Dimensions. Range of observed specimens: diameter of central body 21 (34·0) 47 μ, length of processes 4–25 μ. Number of specimens measured, 160.

Description. A statistical study was made of this species using 20–30 specimens from each of six samples at 40-foot intervals from the Fetcham Mill Borehole. The purpose of this study was to see if the variation in the mean size of *L. siphoniphorum* was directional, and if there was a significant difference in this measurement for

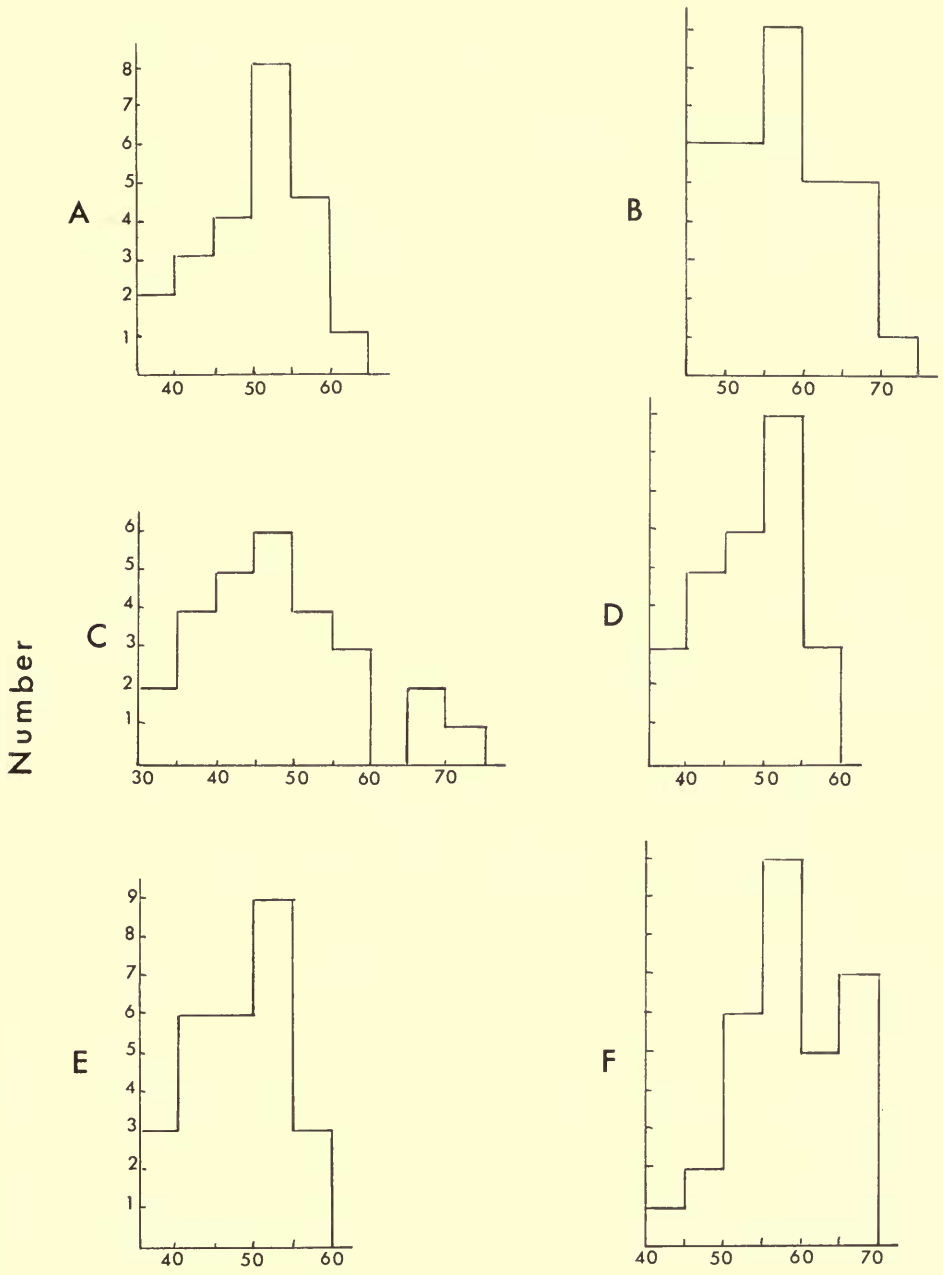

FIG. 15. Overall diameter—frequency histograms of *Litosphaeridium siphoniphorum* (Cookson and Eisenack) at six horizons from Fetcham Mill, Surrey. A. Sample FM 650, B. Sample FM 690, C. Sample FM 730, D. Sample FM 770, E. Sample FM 810, F. Sample FM 840.

successive samples. The measurement taken was the overall diameter. The position of the archaeopyle is always obvious, allowing easy specimen orientation. Thus to make all measurements strictly comparable the overall diameter was always taken in the plane of the archaeopyle.

Histograms (Fig. 15) were drawn for each assemblage. The mean overall diameter for each assemblage varied for each horizon but, unfortunately, the variation was not directional and, therefore, was of little stratigraphic value. The Student's t-test was performed on successive pairs of assemblages to see whether or not they were significantly different (Table A). A probability of 0·05 or less was taken as being significant.

TABLE A

FM 650 FM 690	($\bar{x} = 50{\cdot}0\,\mu$) ($\bar{x} = 56{\cdot}6\,\mu$)	$t = 3{\cdot}08$	(significant difference)
FM 690 FM 730	($\bar{x} = 56{\cdot}6\,\mu$) ($\bar{x} = 48{\cdot}3\,\mu$)	$t = 3{\cdot}16$	(significant difference)
FM 730 FM 770	($\bar{x} = 48{\cdot}3\,\mu$) ($\bar{x} = 48{\cdot}1\,\mu$)	$t = 0{\cdot}084$	(no significant difference)
FM 770 FM 810	($\bar{x} = 48{\cdot}1\,\mu$) ($\bar{x} = 48{\cdot}1\,\mu$)	$t = 0$	(no significant difference)
FM 810 FM 840	($\bar{x} = 48{\cdot}1\,\mu$) ($\bar{x} = 58{\cdot}0\,\mu$)	$t = 5{\cdot}4$	(significant difference)

The results show that there is a significant difference at the 5% level between some of the assemblages with respect to this character. However, all the specimens measured were apparently morphologically identical and differ only in size. Specimens from one sample vary considerably in size but were probably formed by one species of motile dinoflagellate. Thus the size of *L. siphoniphorum* appears to be quite variable and should, at the moment, not be used as a diagnostic feature for the subdivision of this species. The reason for the means in successive samples to be significantly different is probably because of palaeoecological changes in the environment.

REMARKS. All the specimens of *L. siphoniphorum* examined agree fairly closely with the type material from Australia. The Surrey specimens appear to be smaller, but the range of the Australian forms was not given so no true size comparison can be made.

OCCURRENCE. *L. siphoniphorum* is rare to common at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It is present in the Albian sample FM 866, but absent from the Turonian sample, FM 520. It is rare to infrequent in the lower four samples from Saskatchewan—samples Sas 1084, 1023, 967 and 890. This species is also present in the Upper Woodbine Formation of Texas. Thus *L. siphoniphorum* has a wide geographical distribution and a fairly restricted range. It has been recorded from the Albian of Australia, Rumania, Canada and Britain and from the Cenomanian of Australia, Canada and Britain.

Genus *POLYSPHAERIDIUM* Davey & Williams 1966

Polysphaeridium pumilum Davey & Williams

?1955 *Hystrichosphaeridium recurvatum* White; Deflandre & Cookson : 269, pl. 1, fig. 12.
1966*b* *Polysphaeridium pumilum* Davey & Williams : 93, pl. 7, figs. 3, 4.

Dimensions. Range of observed specimens: overall diameter 30–40 μ, diameter of central body 17–25 μ, length of processes 7–10 μ, width of processes 1–1·5 μ, number of processes 38–44. Number of specimens measured, 3.

Occurrence. Only three specimens of *P. pumilum* have been observed, one from sample FM 750 and two from sample FM 770.

Polysphaeridium laminaspinosum Davey & Williams

(Pl. 4, figs. 10, 11)

1966*b* *Polysphaeridium laminaspinosum* Davey & Williams : 94, pl. 8, fig. 8.

Dimensions. Range of observed specimens: diameter of central body 20 (26·8) 29 μ, maximum length of processes 9 (13·7) 17 μ. Number of specimens measured, 8.

Occurrence. *P. laminaspinosum* is rare to very rare, occurring spasmodically throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has not been recorded elsewhere.

Genus *TANYOSPHAERIDIUM* Davey & Williams 1966

Tanyosphaeridium variecalamum Davey & Williams

(Pl. 6, figs. 2, 5)

1966*b* *Tanyosphaeridium variecalamum* Davey & Williams : 98, pl. 6, fig. 7; text-fig. 20.

Dimensions. Range of observed specimens: length of central body 27 (32·3) 43 μ, width 14 (20·1) 24 μ, maximum length of processes 11 (15·0) 24 μ. Number of specimens measured, 14.

Occurrence. *T. variecalamum* is a rare to infrequent species at most horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It is also present in the Albian sample, FM 886, and the Turonian sample, FM 520, both from Fetcham Mill. One specimen was located in the Saskatchewan material, from the Albian sample Sas 1084.

Genus *CALLAIOSPHAERIDIUM* Davey & Williams 1966

Remarks. *Hexasphaera* Clarke & Verdier (1967; 42) is a junior synonym of *Callaiosphaeridium*.

Callaiosphaeridium asymmetricum (Deflandre & Courteville)

(Pl. 6, fig. 6)

1939 *Hystrichosphaeridium asymmetricum* Deflandre & Courteville : 100, pl. 4, figs. 1, 2.
1966*b* *Callaiosphaeridium asymmetricum* (Deflandre & Courteville) Davey & Williams : 104, pl. 8, figs. 9, 10; pl. 9, fig. 2.
1967 *Hexasphaera asymmetrica* (Deflandre & Courtville) Clarke & Verdier: 43, pl. 7, figs. 1–3 text-fig. 17.

Dimensions. Range of observed specimens: diameter of central body 37 (45·8) 58 μ, maximum length of cingular processes 10 (25·0) 32 μ. Number of specimens measured, 6.

Remarks. The author disagrees with the description of Clarke & Verdier (1967) in that the archaeopyle is epitractal, not apical, and that the antapical plate is five-sided, not six-sided, bearing a process at each corner. The position of the three sutural crests separating the large plates has, however, been verified.

Occurrence. *C. asymmetricum* is rare to infrequent at most horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has been recorded in the Albian sample FM 886 and the Turonian sample FM 520, both from Fetcham Mill, but is absent from the North American material.

Genus ***CLEISTOSPHAERIDIUM*** Davey, Downie, Sarjeant & Williams 1966

Cleistosphaeridium heteracanthum (Deflandre & Cookson)

(Pl. 7, fig. 8)

1955 *Hystrichosphaeridium heteracanthum* Deflandre & Cookson : 276, pl. 2, figs. 5, 6; text-figs. 40, 41.
1966 *Cleistosphaeridium heteracanthum* (Deflandre & Cookson) Davey, Downie, Sarjeant & Williams : 168, pl. 2, figs. 6, 7 (See also for earlier references).

Dimensions. Range of observed specimens: shell diameter 42 (53·2) 63 μ, maximum length of processes 9 (13·8) 17 μ. Number of specimens measured, 9.

Occurrence. *C. heteracanthum* is a rare species restricted to the Upper Cenomanian—samples FM 690, 670 and 650 from Fetcham Mill, samples CB 19 and 21 from Compton Bay and sample E 153 from Escalles. It was not recorded from North America.

Cleistosphaeridium multifurcatum (Deflandre)

(Pl. 8, figs. 7, 10)

1937 *Hystrichosphaeridium multifurcatum* Deflandre : 76, pl. 16, figs. 1–3.
1939 *Hystrichosphaeridium multifurcatum* Deflandre; Deflandre & Courteville : 102, pl. 3, fig. 2.
1952 *Hystrichosphaeridium multifurcatum* Deflandre; W. Wetzel : 400, text-fig. 16.
1955 *Hystrichosphaeridium multifurcatum* Deflandre; Valensi : 588, pl. 1, fig. 21; pl. 5, fig. 5.
1960 *Baltisphaeridium multifurcatum* (Deflandre) Klement : 59.

1963 *Hystrichosphaeridium multifurcatum* Deflandre; Górka : 66, pl. 9, figs. 4–6; text-fig. 8, fig. 1.
1966 *Cleistosphaeridium multifurcatum* (Deflandre) Davey, Downie, Sarjeant & Williams: 170.

Dimensions. Range of observed specimens: diameter of central body 39 (55·0) 68 μ, maximum length of processes 8 (11·2) 13 μ. Number of specimens measured, 8.

Occurrence. *C. multifurcatum* is rare at most horizons in the Cenomanian of Fetcham Mill, Compton Bay and Escalles. In a few Upper Cenomanian samples (FM 690, 670 and 650; CB 19, 21 and E 153) it is completely absent. In these samples it seems to be replaced by *C. heteracanthum*. *C. multifurcatum* was not observed in the North American samples.

Cleistosphaeridium armatum (Deflandre) comb. nov.

(Pl. 8, figs. 1, 2, 12)

1937 *Hystrichosphaeridium armatum* Deflandre : 76, pl. 16, figs. 6, 7.
1947 *Hystrichosphaeridium armatum* Deflandre; Deflandre: fig. 1, No. 10.
1952*a* *Hystrichosphaeridium armatum* Deflandre; Deflandre: fig. 14.
1963 *Baltisphaeridium armatum* (Deflandre) Downie & Sarjeant : 91.
1967 *Baltisphaeridium armatum* (Deflandre) Clark & Verdier: 71, pl. 13, fig. 3.

Emended diagnosis. Shell subspherical; shell wall of moderate thickness, densely granular. Processes numerous, fairly broad, rigid, tapering gradually distally. Proximally processes possess longitudinal basal striations; distally simple or giving rise to variable number of small spines. Apical archaeopyle occasionally developed.

Holotype. Slide AJ. 54, Laboratoire de Micropaléontologie, École Practique des Hautes Études, Paris. (Figured by Deflandre 1937, pl. 16, fig. 6). Upper Cretaceous flint from the Paris Basin.

Dimensions. Holotype: shell length 20 μ, width 18–20 μ, length of processes 10–15 μ. Range of Cenomanian specimens: diameter of central body 19 (30·8) 42 μ, maximum length of processes 5 (9·6) 16 μ. Number of specimens measured, 33.

Description. The granules are elongate (*c.* 0·1–0·5 μ in height) so giving the shell surface the appearance of possessing a matting of short hairs. This ornamentation, commented on by Deflandre in the original description of this species, was verified by the present author when examining the type material in Paris.

The processes are all of a similar length on any one specimen and may vary in width from 1 to 3 μ. They are hollow, always closed distally terminating either simply (the extremity may be recurved) or more commonly the distal one quarter of the processes bear a small number of stiff spines (pl. 8, fig. 2). The opening, when observable, possesses an angular margin characteristic of an apical archaeopyle.

Remarks. The specimens studied strongly resemble *C. armatum* as described by Deflandre from Upper Cretaceous flints, one of which was of Cenomanian age. The appearance of the shell surface and form of the processes make this an easily recognizable species.

Occurrence. *C. armatum* is common at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It is also present in the Upper Wood-

bine and Lower Eagle Ford formations of Texas, but has not been observed in the Saskatchewan samples.

Cleistosphaeridium polypes (Cookson & Eisenack) comb. nov.

(Pl. 6, figs. 7, 8)

1962*b* *Hystrichosphaeridium recurvatum* subsp. *polypes* Cookson & Eisenack : 491, pl. 4, figs. 11–13.

Description. The shell is spherical to subspherical and bears numerous slender processes. The shell wall is thin and may be smooth or slightly granular. The processes are narrow, usually less than 1 μ in width for most of their length, broadening slightly proximally. They are closed distally and terminate in a number of short, fine spines. The latter are not so numerous in the English and French specimens as in those from Australia and North America where the distal spines are numerous. A fairly large archaeopyle, probably apical, with an angular margin is often present.

Dimensions. Range of observed specimens: shell diameter 31 (38·4) 47 μ, maximum length of processes 9 (13·4) 18 μ. Number of specimens measured, 20.

Remarks. *C. polypes* was originally described by Cookson & Eisenack from the Aptian–Cenomanian of Australia and was considered to be a subspecies of *Hystrichosphaeridium recurvatum* (White). The resemblance between the two forms is very slight and they are not considered to be closely related. *C. polypes* is placed in this genus because of the presence of numerous closed processes and the probable apical location of the archaeopyle.

Occurrence. *C. polypes* is a very rare species restricted to the Middle and Upper Cenomanian of Fetcham Mill (samples FM 750, 730), Compton Bay (samples CB 9, 17, 21) and Escalles (samples E 189, 177, 165). It is common in the Upper Woodbine formation of Texas, and is present in one sample from Saskatchewan (sample Sas 835).

Cleistosphaeridium polypes var. *clavulum* nov.

(Pl. 6, figs. 9, 10)

1964 *Hystrichosphaeridium recurvatum* subsp. *polypes* Cookson & Eisenack; Cookson & Hughes : 47, pl. 9, fig. 14.

Derivation of name. Latin, *clavulus*, small nail—with reference to the pin-like shape of the processes.

Diagnosis. A variety of *C. polypes* possessing fine, capitate processes. Processes terminating with fine spines are extremely rare.

Type. G.S.M. slide PF 3995(1). Lower Chalk, H.M. Geological Survey Borehole, Fetcham Mill, Surrey at 840 feet depth. Upper Cretaceous (Cenomanian).

Dimensions. Type: diameter of central body 29 by 32 μ, length of processes 12–13 μ. Range: diameter of central body 29 (31·5) 39 μ, maximum length of processes 13 (14·7) 15 μ. Numbers of specimens measured, 10.

Remarks. *C. polypes* var. *clavulum* differs from *C. polypes* in that the processes are capitate, the terminal bulge being flattened and resembling the head of a pin. Two specimens have been observed each possessing one process of the type characteristic of *C. polypes* thus indicating a relationship between the two forms. *C. polypes* probably evolved from this variety, spiny processes replacing the capitate ones.

Occurrence. This variety has only been recorded from the lowermost Cenomanian samples at Fetcham Mill (sample FM 840) and Compton Bay (sample CB 1). It was previously recorded by Cookson & Hughes (1964) from the Upper Albian—basal Cenomanian of England and so appears to be of stratigraphic importance in England for indicating the base of this stage. It does not occur in the lowermost sample from Escalles.

Cleistosphaeridium huguonioti (Valensi) comb. nov.

(Pl. 7, fig. 10)

1955 *Hystrichosphaeridium huguonioti* Valensi : 38, fig. 2a.
1960*a* *Hystrichosphaeridium ancoriferum* Cookson & Eisenack : 8, pl. 2, fig. 11.
1963 *Hystrichosphaeridium ancoriferum* Cookson & Eisenack; Balteş : 586, pl. 6, fig. 13.
1964 *Hystrichosphaeridium ancoriferum* Cookson & Eisenack; Cookson & Hughes : 47, pl. 9, fig. 7.
1964 *Chlamydophorella nyei* Cookson & Eisenack; Cookson & Hughes : 54, pl. 6, fig. 12.
1966 *Cleistosphaeridium ancoriferum* (Cookson & Eisenack) Davey, Downie, Sarjeant & Williams: 167, pl. 9, fig. 1.
1967 *Hystrichosphaeridium huguonioti* Valensi; Clarke & Verdier: 54, pl. 11, fig. 4, 5.

Description. The shell is subspherical; the shell wall is smooth and gives rise to numerous bifurcating processes which are not aligned to any noticeable extent. Most of the specimens possess an apical archaeopyle, the shape of which is usually difficult to determine because of distortion. However, detached apical regions are common and are 6-sided. The processes are hollow, the central cavity often being constricted to some extent along its length, and closed distally and proximally. The sides of the processes are practically parallel, diverging slightly proximally before joining the shell. Distally they give rise to two slightly recurved spines. Cookson & Eisenack comment on the " transparent tips " of the processes. The extremities of the processes are in fact closed by a thin, transparent membrane. The processes may be isolate or a few may be linked together distally by their spines. The shell wall rarely forms a small rounded apical bulge.

Dimensions. Range of observed specimens: diameter of central body 20 (31·8) 45 μ, length of processes up to 8 μ. Number of specimens measured, 30.

Remarks. Cookson & Hughes (1964) described *C. huguonioti* and *Chlamydophorella nyei* from the Upper Albian and Lower Cenomanian of England, distinguishing the latter, with difficulty, by the presence of an outer membrane and an apical bulge. After a detailed examination of numerous Cenomanian specimens it was concluded that *Chlamydophorella nyei* s.s., as described from Australia, does not occur in the English and French Cenomanian and that *C. nyei* as described by Cookson &

Hughes belongs in *Cleistosphaeridium huguonioti*. *C. huguonioti* does occasionally appear to possess a membrane linking some of the processes when their spines are joined distally, and an apical prominence may also rarely be present. Some specimens possess joined processes but apparently no apical prominence, whereas others possess an apical prominence but no joined processes. The presence of distinctive bifurcate processes and an apical prominence indicates that *C. huguonioti* is related to *Chlamydophorella*, the outer membrane of the latter being reduced to a small, transparent membrane at the distal end of each process.

Occurrence. *C. huguonioti* is common throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles (Fig. 22). It is absent from the uppermost sample from Escalles (sample E 153) and from the Turonian sample FM 520. In the Upper Cenomanian at these localities *C. huguonioti* tends to be replaced by its variety, *C. huguonioti* var. *pertusum* nov., which appears to become more abundant as *C. huguonioti* declines. It is present in the Albian sample FM 886 and is common in the Upper Woodbine and Lower Eagle Ford formations of Texas, but was not observed in the Saskatchewan material. This species was first recorded from the Albian–Cenomanian of Australia and is also present in the Albian–Cenomanian of Rumania (Balteş, 1963). Thus *C. huguonioti* appears to be wide-spread geographically and restricted to the Albian and Cenomanian.

Cleistosphaeridium huguonioti var. ***pertusum*** nov.

(Pl. 7, figs. 6, 7, 9)

Derivation of name. Latin, *pertusum*, perforated—with reference to the perforate appearance of the processes.

Diagnosis. A variety of *C. huguonioti* possessing spherical to subspherical, smooth walled shell bearing numerous processes. Processes broad-based, tapering distally and terminating with two small recurved spines. Lumen of processes restricted by transverse septa.

Holotype. G.S.M. slide PF 3040(2). Lower Chalk, H.M. Geological Survey Borehole, Fetcham Mill, Surrey at 670 feet depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: diameter of central body 36 by 36 μ, length of processes 7–9 μ, maximum width of processes distally 2 μ. Range: diameter of central body 24 (34·1) 46 μ, length of processes 6 (8·7) 11 μ, maximum width of processes distally 1 (2·7) 4·5 μ. Number of specimens measured, 24.

Description. The processes taper distally from a fairly broad base (2·5–4 μ in width) to a narrow neck (*c.* 0·5 μ in width) before bifurcating to give two short, recurved spines. The processes are hollow but the lumen is traversed by a number of small septa which thus subdivide it, giving the processes a " holey " or vacuolated appearance. An archaeopyle is only rarely observable.

Remarks. This variety differs from *C. huguonioti* in the form of its processes which are vacuolated, tend to be longer and bear relatively small distal spines. *C. huguonioti* found in the same samples possesses processes which are considerably

wider distally (5·5–7·5 μ). *C. huguonioti* var. *pertusum* appears to have evolved from *C. huguonioti* in the Middle to Upper Cenomanian.

Occurrence. *C. huguonioti* var. *pertusum* occurs only in the Upper Cenomanian, where it is common at all horizons. It first occurs in samples FM 710 (Fetcham Mill), CB 15 (Compton Bay) and E 171 (Escalles). At these horizons it is occasionally difficult to distinguish from *C. huguonioti*. Like *C. huguonioti*, this variety is absent from sample E 153 (Escalles) and FM 520 (Fetcham Mill, Turonian). It has not been observed in the samples from North America.

?Cleistosphaeridium flexuosum Davey, Downie, Sarjeant & Williams

(Pl. 7, figs. 4)

1966 ? *Cleistosphaeridium flexuosum* Davey, Downie, Sarjeant & Williams: 169, pl. 2, fig. 5.

Occurrence. This is a very rare species occurring at most horizons throughout the Cenomanian of Fetcham Mill. It has not been recorded elsewhere.

?Cleistosphaeridium parvum sp. nov.

(Pl. 7, figs. 11, 12)

Derivation of name. Latin, *parvus*, little—with reference to the small size of this cyst.

Diagnosis. Shell ovoidal, small; shell wall smooth, bearing numerous long, fine spines. Spines may be aligned along upper and lower boundaries of cingulum. Cingulum strongly laevo-rotatory. Apical archaeopyle typically developed.

Holotype. B.M. (N.H.) V.51981 (3). Lower Chalk, Bureau de Recherches Géologique et Minières Borehole, Escalles, Pas de Calais at 165 metres depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: length of central body 12 μ, width 11 μ, length of processes 6–11 μ. Range: length of central body 11–14 μ, width 10–13 μ, length of processes 6–12 μ. Number of specimens measured, 5.

Description. The spines are long, very fine, terminate distally in a point and widen only slightly when joining the shell. The cingulum is not always observable but some alignment of the spines parallel to the archaeopyle margin is usually present.

Remarks. ?*C. parvum* resembles only one previously described species, that is *Palaeostomocystis echinulata* Deflandre (1937) from the Upper Cretaceous of France. This species differs in that there are fewer spines (*c.* 12), but is similar in its ovoidal shape, apical archaeopyle, cingulum and small size (6–7 μ long).

The presence of a cingulum has not previously been observed in members of *Cleistosphaeridium* and might later be used as a character in generic subdivision. However, difficulty of observation makes it of dubious value.

Occurrence. ?*C. parvum* is fairly common in three Upper Cenomanian samples from Escalles—E 171, 165 and 159. It has also been observed in a single Lower Cenomanian sample from Compton Bay (CB 5). In all other samples it appears to be absent.

?*Cleistosphaeridium aciculare* sp. nov.

(Pl. 6, figs. 11, 12)

Derivation of name. Latin, *acicularis*, like a needle—with reference to the acuminate shape of the processes.

Diagnosis. Shell spherical to subspherical; shell wall of moderate thickness, densely granular. Processes numerous, finely to broadly acuminate, slightly flexuous, less than one-third of shell diameter in length.

Holotype. B.M. (N.H.) slide V. 51979 (3). Second White Speckled Shale, International Yarbo Borehole No. 17, Saskatchewan at 835 feet depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: diameter of central body 43 by 50 μ, length of processes 12–14 μ. Range: diameter of central body 32 (43·0) 54 μ, maximum length of processes 8 (13·9) 21 μ. Number of specimens measured, 11.

Description. The processes may be finely or broadly acuminate but on each individual their width is constant. On individuals bearing fine processes these are more densely packed than in individuals with broad processes. All intergradations exist between the fine and the broad processed forms. The processes are always pointed distally and occasionally bear small subsidiary spines near their extremities. An archaeopyle has never been observed.

Remarks. ?*C. aciculare* is only tentatively placed in this genus, for although it resembles other members in overall appearance, an apical archaeopyle has not been observed. The numerous acuminate processes and the densely granular shell surface differentiate ?*C. aciculare* from most previously described forms. Most similar seems to be *Exochosphaeridium* (*Hystrichosphaeridium*) cf. *striolatum* (Deflandre) as illustrated by Górka (1963, pl. 10, fig. 6) from the Cenomanian of Poland.

Occurrence. ?*C. aciculare* is common in the following samples from Saskatchewan—Sas 1084, 1023 and 967 (all Albian) and Sas 835 (Cenomanian). It has not been recorded elsewhere.

Genus *SURCULOSPHAERIDIUM* Davey, Downie, Sarjeant & Williams 1966

Surculosphaeridium longifurcatum (Firtion)

(Pl. 8, fig. 9)

1952 *Hystrichosphaeridium longifurcatum* Firtion : 157, pl. 9, fig. 1 ; text-fig. 1, H, K, L and M
1963 *Baltisphaeridium longifurcatum* (Firtion) Downie & Sarjeant: 91.
1966 *Surculosphaeridium longifurcatum* (Firtion) Davey, Downie, Sarjeant & Williams : 163, pl. 8, figs. 7, 11; text-figs. 43, 44.

DIMENSIONS. Range of observed forms: lateral view—diameter of central body 30 (38·3) 47 μ; apical view—diameter of central body 36 (42·2) 50 μ, maximum length of processes 14 (22·2) 29 μ. Mean diameter of archaeopyle, 20 μ. Number of specimens measured, 24.

OCCURRENCE. This is a rare species at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. The only exception is sample FM 730 from Fetcham Mill, where this species is very common, composing 22·5 % of the total microplankton present. The reason for this unusual abundance is unknown. *S. longifurcatum* is also present in the Lower Eagle Ford formation of Texas, but was not observed in the Saskatchewan samples. It has not been observed in the Albian sample (FM 886) or the Turonian sample (FM 520) from Fetcham Mill, and thus appears to be characteristically, Cenomanian.

Genus ***HYSTRICHOKOLPOMA*** Klumpp emend. Williams & Downie 1966

Hystrichokolpoma ferox (Deflandre)

(Pl. 9, figs. 5–7)

1937 *Hystrichosphaeridium ferox* Deflandre : 72, pl. 14, figs. 3, 4.
1966*a* *Hystrichokolpoma ferox* (Deflandre) Williams & Downie : 181.
1967 *Baltisphaeridium ferox* (Deflandre) Clarke & Verdier: 73, pl. 15, fig. 4 (see also for earlier references).

EMENDED DIAGNOSIS. Shell subspherical, densely granular or reticulate. Processes thin walled, granular, often striated, of three kinds: (i) 6 large precingular and 4 large postcingular, possessing wide bases and tapering distally giving rise to 2 or more tubules, typically open; (ii) a single long tubular antapical process and (iii) cingular and sulcal processes, of moderate length, slender and tubular, only joining proximally if at all. Archaeopyle apical.

HOLOTYPE. Slide AH 72, Laboratoire de Micropaléontologie, Ecole Practique des Hautes Etudes, Paris. (Figured by Deflandre 1937*a*, pl. 14, fig. 3). Senonian flint from the Paris Basin.

DIMENSIONS. Holotype: length of shell 46 μ, width 36 μ, overall length 78 μ, length of processes 15–17 μ. Range of Cenomanian specimens: diameter of central body 39 (46·1) 56 μ, maximum length of processes 27 (30·2) 36 μ. Number of specimens measured, 13.

DESCRIPTION. *H. ferox* appears to be a fairly variable species. In some specimens the tabulation is not clearly indicated by the processes which tend to be smaller and may even be closed distally. However, the processes usually are well developed, their bases covering an area of the shell surface which is often slightly raised and of the same shape as a thecal plate. The precingular and postcingular processes are largest and give rise distally to as many as 10 tubules. Each cingular process divides proximally into 2 or 3 long slender tubules aligned along the cingulum. The sulcal processes may proximally divide into two tubules or may consist of a single tubule which is sometimes reduced and closed distally. The antapical process is long, tubular, open distally, and terminates with a smooth or serrate margin.

Remarks. The Cenomanian specimens closely resemble the holotype of *H. ferox*, which was examined in Paris by the author, by kind permission of Professor Deflandre. The processes of the holotype are of the same form as, and similarly positioned to, those of the Cenomanian forms. The antapical process of the holotype, not shown in Deflandre's illustration (1937, pl. 14, fig. 3), is long and tubular.

Occurrence. *H. ferox* is rare to very rare at most horizons throughout the Cenomanian of Fetcham Mill and Escalles, but has not been observed at Compton Bay or in the North American samples. It is also present in the Turonian sample (sample FM 520) from Fetcham Mill. Hence the stratigraphic range is from Aptian (Eisenack 1958) to Upper Cretaceous, probably Senonian (Deflandre 1937).

Genus ***PROLIXOSPHAERIDIUM*** Davey, Downie, Sarjeant & Williams 1966

Diagnosis. Shell elongate ovoidal to ellipsoidal, one pole (apical) typically lost in archaeopyle formation. Opposite pole occupied by one or two antapical processes. Remaining processes arranged in distinct rows, encircling shell and slightly offset at a position corresponding to sulcus. Number of processes exceeds 30. Processes closed proximally, typically but not constantly closed distally; their distal terminations simple, faring in varied fashion, or briefly furcate. Shell surface sometimes bears cover of coarse granules or very short, simple spinelets.

Remarks. The diagnosis has been changed slightly: ' typically but not constantly closed distally ' being inserted in place of ' closed or open distally ', with respect to the processes. The processes of *Prolixosphaeridium* usually taper distally and are closed. Specimens with open tubular processes belong to *Tanyosphaeridium* Davey & Williams (1966*b*).

Prolixosphaeridium conulum sp. nov.

(Pl. 8, figs. 5, 6)

Derivation of name. Latin, *conulus*, cone—with reference to the rather conical shape of the processes.

Diagnosis. Shell elongate ovoidal; shell wall densely granular and bearing moderate number of processes. Processes acuminate to subconical, smooth walled, typically rigid, pointed distally. Processes tend to be aligned in circular manner around shell. Archaeopyle apical.

Holotype. B.M. (N.H.) V.51981 (5). Lower Chalk, Bureau de Recherches Géologiques et Minières Borehole, Escalles, Pas de Calais, at 165 metres depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: shell length 47 μ, width 27 μ, length of processes 11–16 μ. Range: shell length 38 (43·8) 50 μ, width 20 (25·9) 29 μ, maximum length of processes 11 (15·1) 18 μ. Number of specimens measured, 8.

Description. The length of the shell is slightly less than twice the width. The surface granules are relatively large (*c.* 0·2–0·4 μ in width and height); they are

equidistant from one another. The processes (45–60 in number) have broad bases (up to 6 μ) and taper distally to terminate in a point. They are approximately half the shell width in length, hollow and typically rigid, only occasionally being bent near the distal end. In the central region of the shell the processes are aligned, the rows encircling the shell. However, in one longitudinal portion in this region the processes are generally smaller and haphazard in arrangement. This region probably corresponds to the sulcus.

Remarks. The distinctive shape, number and size of the processes distinguish P. *conulum*. A rather similar but longer form was illustrated by Cookson & Eisenack (1958, pl. 8, fig. 11) as *Hystrichosphaeridium parvispinum* Deflandre. This specimen comes from the Aptian of Australia and is said to grade into forms possessing more numerous processes similar to *P. conulum*. Deflandre's species was placed in *Prolixosphaeridium* by Davey, Downie, Sarjeant & Williams (1966).

Two other species are rather similar. The holotype of *P. granulosum* (Deflandre) measures 18 by 33 μ and possesses 20–30 long processes, the latter being approximately equal to the shell width. The number of processes and the relative lengths of the processes, therefore, differentiate this species from *P. conulum*. *P. granulosum* as described by Valensi (1955) from the Upper Cretaceous, and Sarjeant (1962) from the Upper Jurassic, are more similar to *P. conulum* but do not possess conical processes.

P. mixtispinosum (Klement) differs from *P. conulum* by possessing two kinds of processes—(i) approximately 50 processes of moderate length and (ii) numerous fine hairs covering the shell surface.

Occurrence. *P. conulum* has only been observed at certain horizons in the Upper Cenomanian of Fetcham Mill, Compton Bay and Escalles—in samples FM 690, CB 19, E 165, E 159 and E 153.

Genus ***CORONIFERA*** Cookson & Eisenack emend.

Emended diagnosis. Shell subspherical to ovoidal, bearing numerous simple or bifurcating processes. Processes solid or hollow, closed distally, and joined proximally by low crests or membranes. Apical process distinctive, simple or branched. Antapical process large, tubular, often terminating with denticulate margin. Archaeopyle apical.

Type Species. *Coronifera oceanica* Cookson & Eisenack 1958. Lower Cretaceous (Albian); Australia.

Remarks. The diagnosis has been emended to include the presence of an apical archaeopyle and low crests joining the processes, and the positions of the two distinctive processes.

Coronifera differs from *Diphyes* Cookson (1965) in that the processes are never tubular and open distally, and by the presence of a reticulum joining the basal portion of the processes. However, both genera possess a large tubular antapical process and an apical archaeopyle, and are probably closely related.

Coronifera oceanica Cookson & Eisenack

(Pl. 8, figs. 8, 11)

1958 *Coronifera oceanica* Cookson & Eisenack : 45, pl. 12, figs. 5, 6.
1958 *Coronifera oceanica* Cookson & Eisenack; Eisenack : 407, pl. 25, fig. 1.
1964 *Coronifera oceanica* Cookson & Eisenack; Cookson & Hughes : 56, pl. 9, figs. 8, 9.
1967 *Coronifera oceanica* Cookson & Eisenack; Clarke & Verdier: 77, pl. 17, fig. 7.

DESCRIPTION. The shell is subspherical to ovoidal, thin-walled, and bears numerous processes of length between one-quarter and one-third of the shell diameter. There is, occasionally, a slight apical prominence beneath the apical process. Fine fibres radiate from the bases of the processes over the shell surface reminiscent of those on the shell surface of *Exochosphaeridium striolatum* (Deflandre). The processes are weak, fairly flexuous and commonly joined to each other by a network of low crests or fine membranes. The latter may be proximal or may extend along the entire length of the processes. Distally the processes are closed and may be simple, bifurcate or trifurcate. A large tubular process is present at the antapex; it is open distally and terminates with a denticulate margin. At the apex, when attached, there is a process which is only slightly larger than the typical processes but is usually branched and, therefore, distinctive. The large archaeoplye, developed in the majority of specimens, has an angular margin and forms opposite the antapical process.

A number of specimens of *C. oceanica* were observed in the Albian sample from Fetcham Mill (FM 886). They resemble the specimens of Eisenack (1958) from the Aptian of Germany in that the processes are fewer, more solid and are usually simple.

DIMENSIONS. Range of observed specimens: diameter of central body 31 (40) 54 μ, maximum length of processes 11 (15·3) 22 μ. Number of specimens measured, 15.

REMARKS. *C. oceanica* has previously been recorded from the Upper Aptian of Germany (Eisenack, 1958), Albian of Australia (Cookson & Eisenack, 1958) and basal Cenomanian of England (Cookson & Hughes, 1964). The surface reticulation was not described in the Australian type material but appears to be present on the photographed specimens. It was first commented on by Cookson & Hughes.

OCCURRENCE. In addition to the German and Australian records, *C. oceanica* is infrequent to common at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles, and is also common in the Albian sample (FM 886) from Fetcham Mill. It was not present in the Turonian sample (FM 520). One specimen was observed in the North American material, in sample Sas 1084 (Albian) from Saskatchewan. Thus the known stratigraphic range is from Upper Aptian to Cenomanian.

Cyst-Family **EXOCHOSPHAERIDIACEAE** Sarjeant & Downie 1966

Genus ***EXOCHOSPHAERIDIUM*** Davey, Downie, Sarjeant & Williams 1966

REMARKS. *Exochosphaeridium* differs from *Trichodinium* Eisenack & Cookson (1960) in that the latter possesses a well developed cingulum.

Exochosphaeridium phragmites Davey, Downie, Sarjeant & Williams

(Pl. 7, fig. 5)

1966 *Exochosphaeridium phragmites* Davey, Downie, Sarjeant & Williams: 165, pl. 2, figs. 8–10.

Dimensions. Range of observed specimens: maximum diameter of central body 41 (51·9) 67 μ, minimum diameter of central body 32 (46·7) 57 μ, maximum length of processes 10 (18·5) 40 μ. Number of specimens measured, 18.

Remarks. Superficially *E. phragmites* resembles *E. striolatum* (Deflandre) which, however, has a definitely striated periphragm. *Trichodinium paucispinum* Eisenack & Cookson (1960) is also similar but has fewer processes and a well developed cingulum.

Occurrence. *E. phragmites* is rare at most horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles, and is recorded from the Albian sample, FM 886. It has not been recorded in the North American material.

Exochosphaeridium pseudohystrichodinium (Deflandre)

(Pl. 11, figs. 4, 5)

1937 *Hystrichosphaeridium pseudohystrichodinium* Deflandre : 73, pl. 15, figs. 3, 4.
1966 ?*Exochosphaeridium pseudohystrichodinium* (Deflandre); Davey, Downie, Sarjeant & Williams : 166.
1967 *Baltisphaeridium pseudohystrichodinium* (Deflandre); Clarke & Verdier: 75, pl. 15, fig. 7. (see also for earlier references).

Emended diagnosis. Shell spherical to ovoidal; shell wall thick, with pitted surface. Processes numerous, slightly fibrous, occasionally bifurcating medially, slender, broadening slightly proximally; distally truncated or terminated with small bifurcation. Cingular processes rarely aligned. Apical process sometimes branched and slightly larger than normal. Archaeopyle precingular, formed by loss of one or two plate areas.

Holotype. Slide AH. 55, Laboratoire de Micropaléontologie, École Practique des Hautes Études, Paris. (Figured by Deflandre 1937, pl. 15, fig. 3). Upper Cretaceous flint from the Paris Basin.

Dimensions. Range of type material: shell length 49 to 54 μ, shell width 38 to 45 μ, overall length 80–90 μ. Range of observed specimens: diameter of central body 35 (43·8) 54 μ, maximum length of processes 13 (16·8) 21 μ. Number of specimens measured, 12.

Description. The shell wall is moderately thick (*c.* 1·5 μ), pitted (never striated), and bears a large number of broad-based processes. All the processes appear to be basically the same except for the apical process which is typically branched and is usually larger than normal.

The author was permitted, through the courtesy of Professor Deflandre, to make a detailed examination of the holotype and paratype. In the holotype the cingular processes were arranged in a definite circular manner around the shell. Such an

alignment was not observed with certainty in any of the Cenomanian specimens studied. The archaeopyle, present in the paratype, is precingular and usually formed by the loss of two plate areas.

Remarks. The Cenomanian specimens differ from the holotype only in that aligned circular processes were not observed. This may be due to unfavourable preservation or orientation of the specimens. The diagnosis of *E. pseudohystrichodinium* has been emended to include a description of the apical process and the archaeopyle.

The overall form of *E. pseudohystrichodinium* resembles species included in the "*hirsutum*" group, but the typical fibrous shell periphragm is absent. The formation of the archaeopyle by the loss of two precingular plates has also been observed in *E. striolatum* var. *truncatum* nov., indicating a relationship.

Occurrence. This species is rather restricted, being common in samples FM 690, E 165 and E 159 and rare in samples FM 750, E 207 and FM 520 (Turonian). It appears, therefore, to be most common in the Upper Cenomanian. It was not recorded in the samples from North America. The recorded stratigraphic range is from Cenomanian to Eocene (Pastiels 1948).

Exochosphaeridium striolatum (Deflandre) comb. nov.

1937 *Hystrichosphaeridium striolatum* Deflandre : 72, pl. 15, figs. 1, 2.

Diagnosis. Shell subspherical to ovoidal. Processes numerous, variable, fibrous, often bifurcate medially and sometimes terminating with small fork. Processes distally may be pointed or blunted. Fibres pass down length of processes onto shell surface and there join with similar fibres from adjacent processes. Apical process and precingular archaeopyle may be present.

Holotype. Slide AH. 89, Laboratoire de Micropaléontologie, École Practique des Hautes Études, Paris. (Figured by Deflandre 1937, pl. 15, fig. 1). Upper Cretaceous flint from the Paris Basin.

Remarks. Through the courtesy of Professor Deflandre, I was able to examine the holotype and paratype of *E. striolatum*. On the holotype one process appeared to be unusually thick and may have been apical in position. Neither holotype nor paratype was observed to possess an archaeopyle but this may have been due to the fact that the lower surfaces of the specimens were extremely dark and could not be studied.

Exochosphaeridium striolatum (Deflandre) var. ***truncatum*** nov.

(Pl. 7, figs. 1–3)

Derivation of name. Latin, *truncatus*, shorten by cutting off—with reference to the truncated extremities of the processes.

Diagnosis. A variety of *E. striolatum* possessing subspherical to ovoidal shell; shell wall fibrous or lightly pitted. Processes numerous, typically fibrous and blunted

distally, slender or subtriangular, rarely branched. Apical process large, often foliate. Precingular archaeopyle, commonly present, formed by loss of two plate areas, rarely one.

HOLOTYPE. B.M. (N.H.) V.51982 (1). Lower Chalk, Bureau de Recherches Géologiques et Minières Borehole, Escalles, Pas de Calais, at 159 metres depth. Upper Cretaceous (Cenomanian).

DIMENSIONS. Holotype: diameter of central body 66 by 67 μ, length of processes 17–22 μ. Range: diameter of central body 34 (56·1) 81 μ, maximum length of processes 6 (17·8) 27 μ. Number of specimens measured, 24.

DESCRIPTION. The shell possesses a moderately thick wall (*c.* 1 μ) but it is quite often distorted, especially when an archaeopyle is developed. The shell surface (periphragm) is typically fibrous; the fibres pass down the length of the processes onto the shell surface and, there, join up with similar fibres from adjacent processes. Some specimens are less conspicuously fibrous, the fibres being apparent near the bases of the processes and only extending a little way onto the shell surface. The remainder of the shell surface in these forms is lightly pitted. The processes may be fairly slender to subtriangular and are occasionally joined proximally. A small number of processes are subdivided medially. The processes are typically truncated distally but may be slightly bulbous. Process alignment was not observed.

The apical process is larger than the other processes and often foliate; the endophragm occasionally forms a small apical bulge beneath it. The archaeopyle is typically formed by the removal of two precingular plates, as is apparent by its shape. Rarely only one plate is lost. Detached opercula consisting of two precingular plates have been located (pl. 7, fig. 3).

REMARKS. *E. striolatum* var. *truncatum* nov. is a member of the "*hirsutum*" group, a group which is characterized by having fibres radiating from the bases of the processes over the shell surface. The truncate nature of the processes, although obvious, has not previously been remarked on. *Exochosphaeridium spinosum* var. *deflandrei* (Lejeuner-Carpentier 1941) is similar, the processes sometimes being bulbous distally, but they are very slender and appear never to be truncated. Two other forms, *E. striolatum* (Deflandre) (illustrated by Lejeune-Carpentier 1941 as *Hystrichosphaeridium hirsutum* text-figs. 1–4) and *E.* (*Hystrichosphaeridium*) cf. *hirsutum* (Cookson & Eisenack 1958), are also comparable, differing in that their processes are not truncated. *Baltisphaeridium bifidum* Clarke & Verdier (1967) is similar but possesses fewer and more slender processes which, however, are bifid distally. The above forms all belong to the "*hirsutum*" group and are rather similar, differing only in the detail form of the processes and perhaps in archaeopyle formation, which is noted here for the first time.

Although the precingular archaeopyle is typically, but not always, formed by the loss of two plate areas, this is not considered reason enough for the erection of a new genus. This species may indicate a trend towards the genus *Lingulodinium* Wall (1967) where four or five precingular plate areas are lost.

OCCURRENCE. *E. striolatum* var. *truncatum* is infrequent to fairly common at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles.

At Fetcham Mill it has also been recorded from the Albian (sample FM 886) and Turonian (sample FM 520). A single specimen was obtained from the Upper Woodbine of Texas, but the species was absent from the Saskatchewan samples.

OTHER SPECIES

The following species and variety are here included in *Exochosphaeridium* on the basis of similarity in structure:

Exochosphaeridium spinosum (White 1842) comb. nov. 1842 *Xanthidium spinosum* White: Microsc. J., **11**, 35–40, pl. 4 fig. 6.

Exochosphaeridium spinosum var *deflandrei* (Lejeune-Carpentier 1941) comb. nov. 1941 *Hystrichosphaeridium spinosum* var. *defiandrei* Lejeune-Carpentier: Annls. Soc. géol. Belg., **63** (bull, 3), B84, figs. 6, 7.

Cyst-Family **AREOLIGERACEAE** Evitt emend. Sarjeant & Downie 1966

Genus ***CYCLONEPHELIUM*** Deflandre & Cookson emend. Williams & Downie 1966

Remarks. Four species are described from the Cenomanian, *C. distinctum* Cookson & Eisenack being the only one fairly common throughout this stage. *C. membraniphorum* Cookson & Eisenack, *C. vannophorum* sp. nov. and *C. paucispinum* sp. nov. are restricted in occurrence. One species *C. eisenacki* sp. nov., is described from the Albian of Saskatchewan. In the Cenomanian, the genus is most abundant at Escalles, rarest at Saskatchewan and absent from Texas, possibly indicating a preference for an open water environment.

Cyclonephelium distinctum Deflandre & Cookson

(Pl. 11, figs. 6–8, 10; Figs. 16 C, D, F)

1955 *Cyclonephelium distinctum* Deflandre & Cookson : 285, pl. 2, fig. 14.
1963 *Circulodinium deflandrei* Alberti, Balteş: 587, pl. 6, figs. 9–11.
1967 *Cyclonephelium distinctum* Deflandre & Cookson; Clarke & Verdier: 22, pl. 1, figs. 6, 7. (see also for earlier references).

Description. This species is extremely variable, as pointed out by Cookson & Eisenack (1962), and a member of most Cenomanian assemblages studied. The shell, which is always somewhat flattened, may be subcircular to ovoidal in outline and has a smooth or lightly granular shell wall. The regular outline is sometimes broken by an apical protuberance and more rarely by two reduced, antapical horns. The latter are of unequal size and when present the antapical region is slightly concave (Fig. 16F). The bald areas, typical of this genus, may occupy almost all of the ventral and dorsal surfaces of the shell leaving only the peripheral regions to bear processes, or may be practically invisible beneath the encroaching processes. Usually, however, these bald areas are circular to ovoidal in shape and occupy approximately thirty per cent of each side of the shell. The processes are usually abundant, extremely variable in form and typically under one-third of the shell width in length. They are solid and usually widen distally and proximally, may be fine or taeniate, and are often distally bifurcate. The bases of the processes are

occasionally thickened and rarely a line of thickening on the shell surface joins one process with a neighbouring one. Equally rarely, and only when the processes are broad, they may be joined distally.

A large apical archaeopyle is always present. This is angular, possesses a pronounced zigzag margin and on the ventral surface usually a relatively deep sulcal notch. Although the archaeopyle is always discernible, the operculum is sometimes still attached. It then behaved as a lid, returning to its original position after the escape of the encysted organism.

Dimensions. Range of observed specimens: height of shell (operculum absent) 41 (54·5) 82 μ, width 48 (61·8) 81 μ, maximum length of the processes 4 (10·7) 21 μ. Number of specimens measured, 50.

Remarks. *C. distinctum* appears to be extremely variable, and specimens showing extremes in variation sometimes appear to be transitional to other species.

Occurrence. Found throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles, and rare to common at all horizons. Two samples from Saskatchewan, samples Sas 890 and Sas 805, also contain *C. distinctum*. The species had a wide geographical distribution throughout most of the Cretaceous and is of little value in detailed stratigraphy.

Cyclonephelium membraniphorum Cookson & Eisenack

(Pl. 11, fig. 9)

1958 *Cyclonephelium compactum* Deflandre & Cookson : 48, pl. 12, fig. 8 only.
1962*b* *Cyclonephelium membraniphorum* Cookson & Eisenack : 495, pl. 6, figs. 8–14.
1964 *Cyclonephelium membraniphorum* Cookson & Eisenack; Cookson & Hughes : 44, pl. 10, figs. 5, 6.
1967 *Cyclonephelium membraniphorum* Cookson & Eisenack; Clarke & Verdier: 23, pl. 2, figs. 1, 2.

Description. The shell is always dorso-ventrally flattened, both the apex and antapex being circular to subcircular in outline. An apical archaeopyle is always developed, with a zigzag margin and sulcal notch. The bald areas, typical of this genus, may be relatively large or quite small and are surrounded by high membranes. The latter are braced by stout supports which arise from lines of thickening on the shell surface. These lines of thickened periphragm may be curved and may form semi-circular rings. When the latter are present, the membranes are in the form of wide tubular projections. The periphragm of the shell wall and the membranes is granular or pitted. The membranes may sometimes be fenestrate.

In some specimens attributed to *C. membraniphorum* the bald areas are practically non-existent. The membranes in these forms are particularly well developed and commonly are in the form of wide tubes or funnels. Distally they have a subcircular to polygonal outline and may possess a thickened outer rim bearing irregular pieces of periphragm (Pl. 11, fig. 9).

Dimensions. Range of observed specimens: length of shell (operculum missing) 37 (50·6) 79 μ, width 41 (54·1) 82 μ, maximum height of membranes 6 (13·3) 26 μ. Number of specimens measured, 16.

Remarks. Many of the specimens observed appear identical with the Albian to Cenomanian forms from Australia, except that the former are considerably smaller, the largest of them only falling within the size range of the type material. It is not thought practical to separate the European forms solely on the size distinction and they have, therefore, been placed in the Australian species. An interesting variation is the apparent absence of the bald areas, although the overall shape and the apical archaeopyle typical of *Cyclonephelium* are present.

Occurrence. In addition to the Australian records, *C. membraniphorum* is rare and spasmodic throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles, though absent elsewhere. This species has also been recorded from the Turonian and Lower Senonian by Clarke & Verdier (1967).

Cyclonephelium vannophorum sp. nov.

(Pl. 9, fig. 3: Pl. 11, figs. 11, 12; Fig. 16E)

Derivation of name. Latin, *vannophorum*, fan-bearer—with reference to the fan-shaped processes.

Diagnosis. Shell subcircular in outline, with slight apical prominence and one or two reduced antapical horns. Shell wall coarsely granular with areas devoid of processes of moderate size. Processes numerous, short, solid, of irregular shape and often confluent distally. Apical archaeopyle with zigzag margin.

Holotype. B.M. (N.H.) slide V.51986 (1). Lower Chalk, Compton Bay, Isle of Wight at 15 feet 6 inches above the base of the Cenomanian. Upper Creatceous (Cenomanian).

Dimensions. Holotype: length of shell (including operculum) 65 μ, width 62 μ, length of processes up to 8 μ. Range: length of shell (without operculum) 47 (57·8) 70 μ, width 56 (65·5) 78 μ, maximum length of processes 3 (5·3) 8 μ. Number of specimens measured, 11.

Description. When two antapical horns are present the portion of the shell between them is concave and from this region a broad furrow passes towards the apex. The furrow or sulcus decreases in width and depth in this direction and disappears just posterior to the archaeopyle margin. The processes vary greatly in size from mere enlarged granules (0·5 μ) to 8 μ in length. In the larger processes the stem is quite narrow, the distal third widening rapidly (Pl. 9, fig. 3) and is sometimes bifurcate. The processes are often joined to form a short line on the shell surface. Rarely the cingulum is just discernible by a concentration of small processes along its borders.

Remarks. *C. vannophorum* sp. nov. is most closely comparable to ?*C. attadalicum* Cookson & Eisenack (1962*b*) from the Aptian/Albian of Australia. The processes are similar in form but the shell of ?*C. attadalicum* is more polygonal and the cingulum is always well defined.

Occurrence. *C. vannophorum* has only been recorded from the Lower Cenomanian sample CB 3 (Compton Bay) and it there comprises about 2% of the micro-

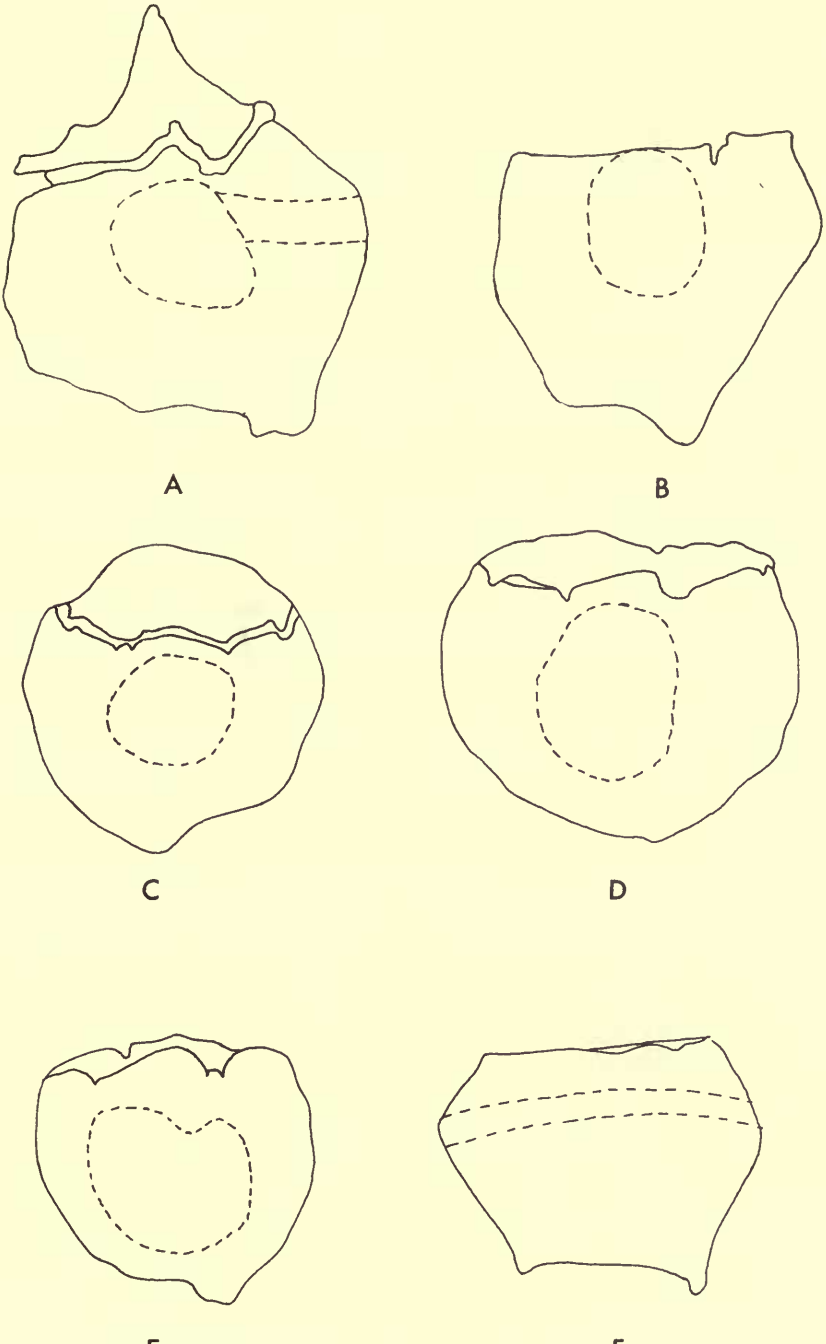

FIG. 16. *Cyclonephelium eisenacki* sp. nov., A. Complete specimen (× 700). B. Specimen illustrating apical archaeopyle (× 700). *Cyclonephelium distinctum* Deflandre & Cookson, C. D. and F. Illustrating variation in the shape of the shell of this species (processes removed) (× 700). *Cyclonephelium vannophorum* sp. nov., E. Specimen with well developed apical archaeopyle (processes removed) (× 700).

plankton content. The unusual distribution and the similarity to a Lower Cretaceous species indicate that *C. vannophorum* is possibly a derived form.

Cyclonephelium paucispinum sp. nov.

(Pl. 9, figs. 1, 2)

Derivation of name. Latin, *paucus*, few; *spina*, thorn—with reference to the scarcity of the processes.

Diagnosis. Shell subpolygonal in outline with well defined antapical horn. Shell wall lightly to coarsely granular, bearing small number of irregularly distributed processes confined to peripheral region of shell. Processes of moderate size, solid and widening distally. Apical archaeopyle with a zigzag margin and sulcal notch.

Holotype. B.M. (N.H.) V.51981 (2). Lower Chalk, Bureau de Recherches Géologiques et Minières Borehole, Escalles, Pas de Calais at 165 metres depth. Upper Cretaceous (Cenomanian).

Dimensions. Holotype: length of shell (operculum missing) 54 μ, width 81 μ, length of processes 1·5–12 μ. Range: length of shell (operculum missing) 40 (72·4) 92 μ, width 54 (87·0) 112 μ, maximum length of processes 5 (10·2) 19 μ. Number of specimens measured, 12.

Description. The shell is subpolygonal in outline, the cingular region being the widest portion of the shell. Posteriorly there is a pointed antapical horn. The few processes present are of moderate size and if close together tend to anastomose both distally and proximally.

Remarks. The large size, the paucity of processes and the subpolygonal shape of the shell distinguish *C. paucispinum* sp. nov. from all previously described species. The processes most closely resemble those of *C. distinctum* but are fewer in number.

Occurrence. *C. paucispinum* is rare in samples E 165, CB 3, and common in sample CB 11. The distribution is, therefore, rather erratic in the Lower, Middle and Upper Cenomanian.

Cyclonephelium eisenacki sp. nov.

(Pl. 8, figs. 3, 4; Pl. 9, fig. 4; Figs. 17A, B)

1960 *Aptea cf. polymorpha* Eisenack & Cookson : **9**, Pl. 3, figs. 2–4.

Derivation of name. The species is named after Professor A. Eisenack.

Diagnosis. Shell subtriangular, flattened, with convex sides. Apical horn well developed; antapical horns, if present, very reduced. Greater part of shell surface ornamented by complex network of low crests and short, capitate processes. In centre of both dorsal and ventral sides there is a circular area devoid of ornamentation. Apical archaeopyle always present.

HOLOTYPE. B.M. (N.H.) V. 51980(2). Upper Lower Colorado (Fish Scale Zone?), International Yarbo Borehole No. 17, Saskatchewan at 1023 feet depth. Lower Cretaceous (Albian).

DIMENSIONS. Holotype: shell length 70 μ, width 66 μ, height of crests 1–5 μ. Range: shell length 70–92 μ (4 complete specimens measured); shell length (operculum missing) 55 (63·1) 71 μ, width 66 (72·1) 84 μ, height of crests 2 (4·2) 7 μ. Number of specimens measured, 12.

DESCRIPTION. The shell surface is ornamented by a very characteristic network of low crests or lamellae which are often broken, so forming isolated processes. A poorly-marked cingulum, outlined by the crests, is occasionally discernible. The apical operculum is often in position.

REMARKS. The illustrations of *Aptea* cf. *polymorpha* indicate that these specimens belong in the genus *Cyclonephelium* and may well be conspecific with the Canadian specimens here described. This species differs from *Aptea polymorpha* Eisenack (1958) by the absence of the numerous fine processes and the outer membranous structure which they support. *Pseudoceratium turneri* Cookson & Eisenack (1958), from the Aptian/Albian of Australia, possesses a similar but stronger ornamentation. Also the apical and antapical horns are usually much better developed, although the specimen of *P. turneri* illustrated (*loc. cit.* pl. 5, fig. 5), approaches a number of the *C. eisenacki* examples.

OCCURRENCE. *C. eisenacki* sp. nov. is fairly common in two samples from Saskatchewan, samples Sas 1084 and 1023. It has not been recorded elsewhere in the material examined.

Cyst-Family **ADNATOSPHAERIDIACEAE** Sarjeant & Downie 1966

Genus ***ADNATOSPHAERIDIUM*** Williams & Downie 1966

Adnatosphaeridium chonetum (Cookson & Eisenack) comb. nov.

(Pl. 10, figs. 11, 12.)

1962*b* ?*Cannosphaeropsis choneta* Cookson & Eisenack : 493, pl. 4, figs. 8–10.

DESCRIPTION. The shell is spherical to subspherical and bears a number of more or less tubular processes which possess bands of thickening for support. The processes are usually joined to their neighbour either along their entire length, or only distally by membranes. However, isolated tubular processes are occasionally visible. The impression obtained from most specimens is of a complex membranous network perpendicular to the shell surface. A well developed apical archaeopyle is typically present.

DIMENSIONS. Range of observed specimens: shell diameter 27 (34·1) 46 μ, length of processes 6 (10·4) 24 μ. Number of specimens measured, 15.

REMARKS. The Cenomanian specimens examined strongly resemble, but are slightly smaller than, the type material from the Cenomanian of Australia. This

species, tentatively placed in *Cannosphaeropsis* by Cookson & Eisenack, is here transferred to *Adnatosphaeridium* because of the presence of interconnecting processes and an apical archaeopyle.

Occurrence. Apart from the Australian occurrence, it is infrequent to common in the Middle and Upper Cenomanian of Fetcham Mill and Escalles, not occurring below samples FM 790 and E 195. Only one specimen was recorded from Compton Bay, in sample CB 19.

Cyst-Family **HYSTRICHOSPAERACEAE** O. Wetzel emend. Sarjeant & Downie 1966

Genus ***HYSTRICHOSPHAERA*** O. Wetzel emend. Davey & Williams 1966

Hystrichosphaera ramosa var. ***ramosa*** (Ehrenberg)

(Pl. 10, figs. 1, 2, 5)

1838 *Xanthidium ramosum* Ehr.: pl. 1, figs. 1, 2, 5.
1966*a* *Hystrichosphaera ramosa* (Ehr.) var. *ramosa* Davey & Williams : 33, pl. 1, figs. 1, 6; pl. 3, fig. 1; text-fig. 8. (See also for earlier references).
1967 *Hystrichosphaera furcata* (Ehr.) Clarke & Verdier: 48, pl. 8, figs. 12, 13.

Dimensions. Range of observed specimens: diameter of central body 29 (40·7) 56 μ, maximum length of processes 13 (19·8) 27 μ. Number of specimens measured, 32.

Occurrence. This variety has a known stratigraphic range from the Oxfordian (Jurassic) to the Ypresian (Eocene). It is a common variety throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles, and is rare to infrequent in the material from Saskatchewan and Texas.

Hystrichosphaera ramosa (Ehrenberg) var. ***gracilis*** Davey & Williams

1955 *Hystrichosphaera ramosa* (Ehr.) Deflandre & Cookson : 263, pl. 5, fig. 8.
1963 *Hystrichosphaera ramosa* (Ehr.) Górka : 48, pl. 6, figs. 6, 7.
1966*a* *Hystrichosphaera ramosa* (Ehr.) var. *gracilis* Davey & Williams : 34, pl. 1, fig. 5; pl. 5, fig. 6.

Dimensions. Range of observed specimens: diameter of central body 28–35 μ, maximum length of processes 16–22 μ. Number of specimens measured, 5.

Occurrence. The known stratigraphic range of this variety is from the Cenomanian (England) to the Miocene (Australia). It is rare to infrequent at most horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles, but has not been recorded in the North American material.

Hystrichosphaera ramosa (Ehrenberg) var. ***multibrevis*** Davey & Williams

(Pl. 10, figs. 3, 4)

1955 *Hystrichosphaera furcata* (Ehr.) Valensi : 586, pl. 4, fig. 4; pl. 5, fig. 12.
1958 *Hystrichosphaera furcata* (Ehr.) Eisenack : 406, pl. 25, figs. 4–8.
1966*a* *Hystrichosphaera ramosa* (Ehr.) var. *multibrevis* Davey & Williams : 35, pl. 1, fig. 4; pl. 4, fig. 6; text-fig. 9.

Dimensions. Range of observed specimens: diameter of central body 31 (39·7) 51 μ, maximum length of processes 10 (14·3) 21 μ. Number of specimens measured, 13.

Occurrence. *H. ramosa* var. *multibrevis* has a stratigraphic range from the Lower Cretaceous (Hauterivian) to the Eocene (Ypresian). It is rare to infrequent in all samples examined from Fetcham Mill, Compton Bay and Escalles. It has also been recorded from the Lower Cretaceous (Albian) of Saskatchewan, in samples Sas 967, 1023 and 1084.

Hystrichosphaera ramosa (Ehrenberg) var. ***reticulata*** Davey & Williams

1966*a* *Hystrichosphaera ramosa* (Ehr.) var. *reticulata* Davey & Williams : 38, pl. 1, fig. 2.

Dimensions. Range of observed specimens: diameter of central body 33 (45·2) 59 μ, maximum length of processes 13 (15·3) 17 μ. Number of specimens measured, 13.

Occurrence. This variety is rare to infrequent at most horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has also been recorded in two Albian samples from Saskatchewan, samples Sas 967 and 1084.

Hystrichosphaera cingulata var. ***cingulata*** (O. Wetzel)

1933 *Cymatiosphaera cingulata* O. Wetzel : 28, pl. 4, fig. 10.
1966*a* *Hystrichosphaera cingulata* (O. Wetzel) Davey & Williams : 38, pl. 1, fig. 9. (See also for earlier references).
1967 *Hystrichosphaera cingulata* var. *cingulata* (O. Wetzel) Clarke & Verdier: 45, pl. 8, figs. 9, 10.

Dimensions. Range of observed specimens: diameter of central body 26 (36·8) 48 μ, maximum height of crests 5 (7·0) 13 μ. Number of specimens measured, 16.

Occurrence. *H. cingulata* is infrequent at all horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It has not been observed in the North American material. The recorded stratigraphic range is from Albian to Middle Miocene.

Hystrichosphaera cingulata (O. Wetzel) var. ***reticulata*** Davey & Williams

1966*a* *Hystrichosphaera cingulata* var. *reticulata* Davey & Williams : 39, pl. 1, fig. 10; pl. 2, fig. 4.
1967 *Hystrichosphaera cingulata* var. *perforata* Clarke & Verdier : 46, pl. 9, figs. 2–4, text-fig. 19.

Dimensions. Range of observed specimens: diameter of central body 33 (42·8) 59 μ, maximum height of crests 7 (10·2) 17 μ. Number of specimens measured, 14.

Occurrence. *H. cingulata* var. *reticulata* is rare to infrequent throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It appears to be slightly more common in the Middle and Upper Cenomanian at these localities. It has not been observed in the North American samples. Clarke & Verdier (1967) also record this variety from the Turonian and Senonian.

Hystrichosphaera crassimurata Davey & Williams

1966*a* *Hystrichosphaera crassimurata* Davey & Williams : 39, pl. 1, fig. 11.
1967 *Hystrichosphaera cingulata* var. *polygonalis* Clarke & Verdier: 47, pl. 8 figs. 7, 8, text-fig. 20.

Dimensions. Range of observed specimens: diameter of central body 36–46 μ, height of crests, up to 14 μ. Number of specimens measured, 4.

Occurrence. *H. crassimurata* is very rare to rare in the Middle and Upper Cenomanian of Fetcham Mill, Compton Bay and Escalles, the lowest samples in which it is found being FM 790, E 195 and CB 9. It has also been recorded from the Upper Woodbine Formation of Texas but is absent from the Saskatchewan material.

Hystrichosphaera crassipellis Deflandre & Cookson

1954 *Hystrichosphaera crassipellis* Deflandre & Cookson: text-fig. 5.
1966*a* *Hystrichosphaera crassipellis* Deflandre & Cookson; Davey & Williams : 40, pl. 1, figs. 7, 8. (See also for earlier references).
1967 *Hystrichosphaera crassipellis* Deflandre & Cookson; Clarke & Verdier: 48, pl. 8, fig. 11; pl. 9, fig. 1.

Dimensions. Range of observed specimens: diameter of central body 34 (47·9) 68 μ, maximum length of processes 10 (17·8) 29 μ. Number of specimens measured, 19.

Occurrence. *H. crassipellis* is rare at most horizons throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles; it has not been recorded in the North American material. The recorded stratigraphic range is from Cenomanian to Middle Miocene (Gerlach 1961).

Genus ***ACHOMOSPHAERA*** Evitt 1963

Achomosphaera ramulifera (Deflandre)

(Pl. 10, fig. 7)

1935 *Hystrichosphaera* cf. *ramosa* (Ehr.) Deflandre : pl. 5, fig. 11.
1966*a* *Achomosphaera ramulifera* (Deflandre) Davey & Williams : 49, pl. 2, fig. 3. (See also for earlier references).
1967 *Achomosphaera ramulifera* (Deflandre); Clarke & Verdier: 40, pl. 8, fig. 1.

Dimensions. Range of observed specimens: diameter of central body 36 (44·7) 61 μ, maximum length of processes 16 (25·8) 36 μ. Number of specimens measured, 14.

Occurrence. This species has a known stratigraphic range from the Cenomanian to the Eocene (Pastiels 1948). It is a very rare to infrequent species at most horizons in the Cenomanian from Fetcham Mill, Compton Bay and Escalles. It is absent from the North American samples.

Achomosphaera sagena Davey & Williams

1966*a* *Achomosphaera sagena* Davey & Williams : 31, pl. 2, figs. 1, 2.
1967 *Achomosphaera reticulata* Clarke & Verdier: 41, pl. 8, figs. 2, 3, text-fig. 16.

Dimensions. Range of type material: diameter of central body 35 (48·4) 59 μ, maximum length of processes 17 (20·8) 28 μ. Number of specimens measured, 12.

Occurrence. *A. sagena* is a very rare to rare species occurring spasmodically in the Cenomanian samples from Fetcham Mill, Compton Bay and Escalles. Clarke & Verdier (1967) have also recorded it (as *A. reticulata*) from the Turonian and Senonian.

Genus *Hystrichodinium* Deflandre emend. Clarke & Verdier 1967

Hystrichodinium voigti (Alberti)

(Pl. 10, figs. 6, 10)

1961 *Heliodinium voigti* Alberti : 33, pl. 8, figs. 1–5.
1966*a* *Heliodinium voigti* Alberti; Sarjeant : 142, pl. 16, fig. 2; text-fig. 36.
1967 *Hystrichodinium voigti* (Alberti) Clarke & Verdier: 38.

Description. The shell is ovoidal to subpolygonal. The periphragm is smooth or slightly granular, and forms sutural crests and ribbon-like processes. The former are variably developed, may occasionally be absent, but when present give rise to long, flexuous processes along their length. When the crests are absent the processes arise directly from the shell surface. The processes are not confined to the plate boundaries and may be distributed at random over the shell surface. The processes are thin-walled, typically simple and occasionally terminate with bifurcate or trifurcate extremities. The cingulum (4–5 μ wide) is always delimited by low crests and is strongly helicoid. A precingular archaeopyle, formed by the loss of plate 3″, is typically present. One detached operculum has been located and bears five processes.

Dimensions. Range of observed specimens: shell length 40 (49·6) 62 μ, width 40 (48·4) 58 μ, length of processes 27 (35·6) 48 μ. Number of specimens measured, 11.

Occurrence. *H. voigti* is rare to fairly common and found spasmodically throughout the Cenomanian of Fetcham Mill, Compton Bay and Escalles. It was originally described by Alberti (1961) from the Lower Barremian to ?Lower Aptian of Germany. The specimens described by Sarjeant (1966*a*) are from the Cenomanian of Fetcham Mill.

Hystrichodinium dasys sp. nov.

(Pl. 10, figs. 8, 9)

Derivation of name. Latin, *dasys*, hairy or shaggy—with reference to the abundant hair-like processes.

DIAGNOSIS. Shell subspherical, thin-walled, smooth or slightly granular. Tabulation very faintly marked; cingulum, and more rarely, precingular and postcingular plate boundaries visible. Processes numerous, short, fine and flexuous, aligned along plate boundaries, also intratabular. Archaeopyle not observed.

HOLOTYPE. B.M. (N.H.) V.51982 (3). Lower Chalk, Bureau de Recherches Géologiques et Minières Borehole, Escalles, Pas de Calais at 159 metres depth. Upper Cretaceous (Cenomanian).

DIMENSIONS. Holotype: diameter of central body 58 by 61 μ, length of processes 10–14 μ. Range: diameter of central body 42 (53·0) 70 μ, maximum length of processes 7 (10·6) 14 μ. Number of specimens measured, 13.

DESCRIPTION. The shell, being thin-walled, is always found deformed. Only two specimens possess a faint tabulation. This is best seen in the holotype which has a clear but lightly defined cingulum and two or three precingular and postcingular plate boundaries visible. The numerous processes are hair-like, approximately 0·2 μ wide for most of their length, probably hollow and terminate with a point. The most characteristic feature of the processes is their extreme flexibility.

REMARKS. The characteristic processes and the presence of a tabulation differentiate *H. dasys* sp. nov. very easily from all previously described microplankton species.

OCCURRENCE. This species is rare to common in all samples from Escalles except the lower three (E 201, E 207, and E 213). One specimen was recorded from Compton Bay (sample CB 7) and two from Fetcham Mill (sample FM 520, Turonian). The species was not recorded from the North American material. The distribution of *H. dasys* possibly indicates an environmental difference between Escalles and Fetcham Mill/Compton Bay, perhaps in the depth of water or distance from land.

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PLATE 1

Gonyaulacysta exilicristata sp. nov.

Fetcham Mill Borehole (depth, 730 feet).

FIG. 1. Dorsal surface of holotype. Slide PF. 3987 (1). × 500.
FIG. 2. Ventral surface. Slide PF. 3987. × 500.

Carpodinium obliquicostatum Cookson & Hughes

FIG. 3. Lower Chalk, Fetcham Mill Borehole (depth, 750 feet). Lateral view. Slide PF. 3988. × 500.
FIG. 4. Lower Chalk, Escalles Borehole (depth, 159 metres). Dorsal surface with archaeopyle. Slide E 195/3. × 1250

Histocysta palla sp. nov.

Fetcham Mill Borehole.

FIG 5. Holotype; view of archaeopyle and attached operculum. Slide PF. 3052. × 500.
FIG. 6. Paratype; Antapical view. Slide PF. 3991 (1). × 500.

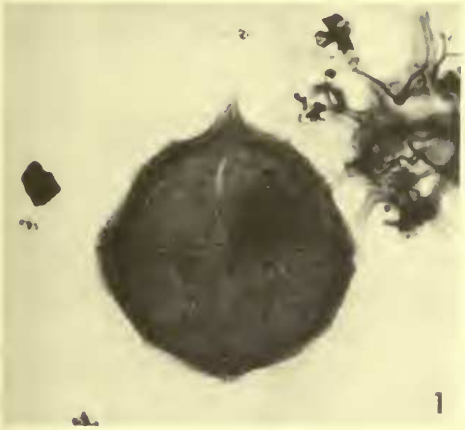
Gonyaulacysta delicata sp. nov.

FIG. 7. Ventral surface of holotype. V. 51979 (1). × 500.
FIG. 8. Paratype; V.51979(2). × 500.

Gonyaulacysta sp. A. Figured specimen.

Lower Chalk, Fetcham Mill Borehole.

FIG. 9. Ventral surface. Slide PF. 3987 (2). × 500
FIG 10. Medial view. Slide PF. 3987 (2). × 500.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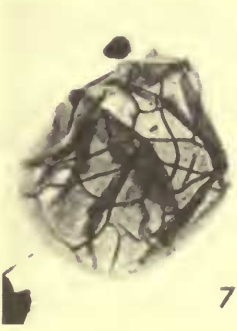
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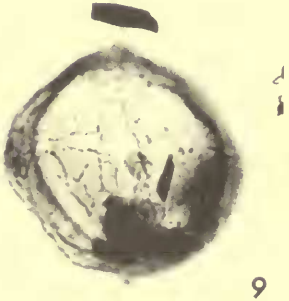
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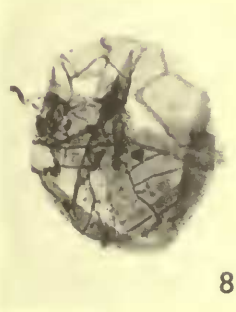
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PLATE 2

Cribroperidinium intricatum sp. nov.

FIG. 1. Ventral surface of holotype. V. 51980 (1). × 500.
FIG. 2. Lower Colorado, Saskatchewan (depth, 1,023 feet). Dorsal surface with operculum *in situ*. V.51980. × 500.
FIG. 3. Lower Colorado, Saskatchewan. Detached operculum. Slide Sas 1023/3. × 500.

Microdinium setosum Sarjeant.

FIG. 4. Lower Chalk, Fetcham Mill Borehole (depth, 840 feet). Lateral view. Slide PF. 3036. × 640.

Microdinium variospinum sp. nov.

FIG. 5. Lower Chalk, Escalles Borehole (depth, 195 metres). Antapical sutural spines visible. Slide E 195/3. × 640.
FIG. 6. Lateral view of holotype. V. 51981 (1). × 640.

?***Microdinium crinitum*** sp. nov.

FIG. 7. Lower Chalk, Fetcham Mill Borehole (depth, 770 feet). Slide FM 770/15. × 640.
FIG. 8. Dorsal surface of holotype Slide PF. 3990 (1). × 640.

Microdinium distinctum sp. nov.

FIG. 9. Ventral surface of holotype. Slide PF. 3989 (1). × 640.
FIG. 10. Dorsal surface of holotype. × 640.
FIG. 11. Lower Chalk, Fetcham Mill Borehole (depth, 790 feet). Ventral surface. Slide FM 790/16. × 640.


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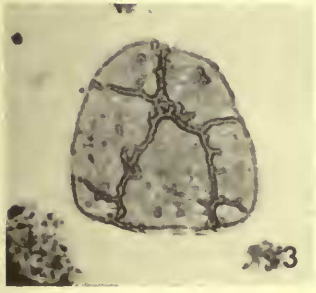
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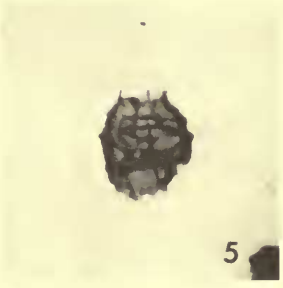
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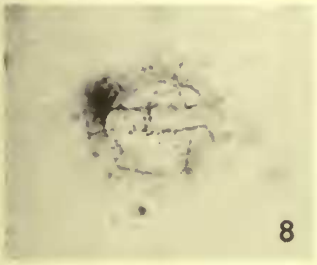
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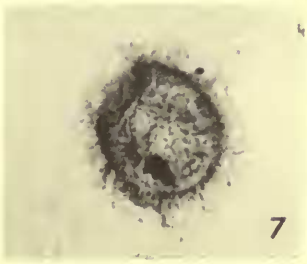
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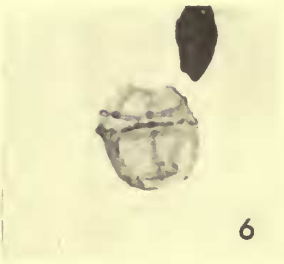
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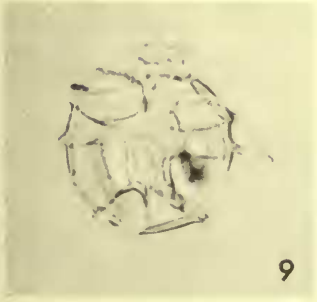
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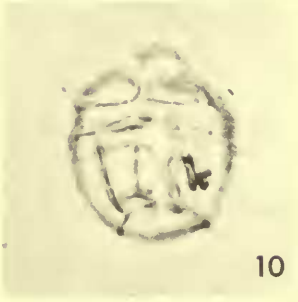
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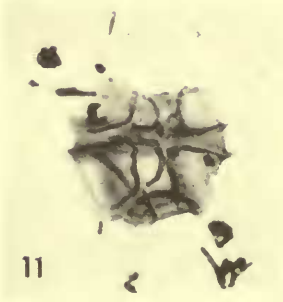
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PLATE 3

Ellipsodinium rugulosum Clarke & Verdier

FIG. 1. Lateral view of specimen showing operculum partially detached. Slide PF. 3988. × 1250.

Fromea amphora Cookson & Eisenack

Lower Chalk, Fetcham Mill Borehole.

FIG. 2. Slide FM 770/6 (depth, 770 feet). × 500.
FIG. 3. Specimen with operculum attached (depth, 650 feet). Slide PF. 3041. × 500.

Microdinium veligerum (Deflandre).

FIG. 4. Lower Chalk, Fetcham Mill Borehole (depth, 650 feet). Antapical view to show crestal cavities. Slide FM 650/5. × 1250.

Apteodinium granulatum Eisenack.

FIG. 5. Lower Chalk, Fetcham Mill Borehole (depth, 690 feet). Ventral surface. Slide FM 690/12. × 640.
FIG. 6. Lower Chalk, Escalles Borehole (depth, 165 metres). Lateral view. V. 51981. × 640.

Cassiculosphaeridia reticulata sp. nov.

FIG. 7. Lower Chalk, Fetcham Mill Borehole (depth, 730 feet). Operculum partially detached. Slide FM 730/9. × 500.

Chytroeisphaeridia euteiches sp. nov.

FIG. 8. Holotype showing archaeopyle. V. 51982 (2). × 500.
FIG. 9. Lower Chalk, Escalles Borehole (depth, 159 metres). Archaeopyle with detached operculum. V. 51982. × 500.

Epelidosphaeridia spinosa (Cookson & Hughes)

Lower Chalk, Fetcham Mill Borehole.

FIG. 10. Dorsal surface. Slide PF. 3992, (depth, 770 feet). × 500.
FIG. 11. Ventral surface with sulcus. Slide PF. 3992 (depth, 770 feet). × 500.
FIG. 12. Complete specimen. Slide PF. 3048 (depth, 770 feet). × 500.


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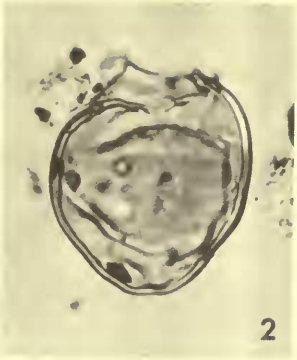
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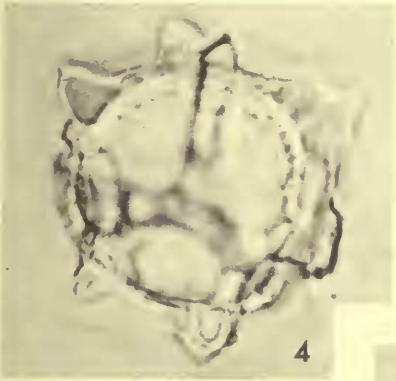
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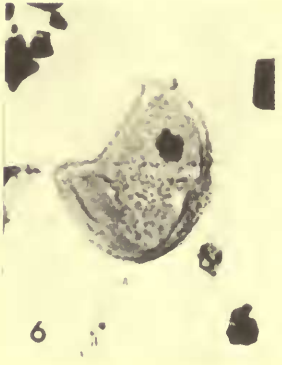
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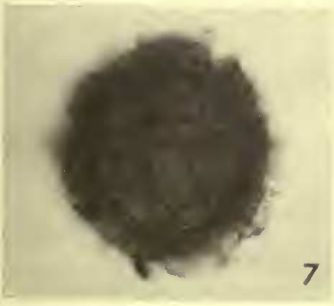
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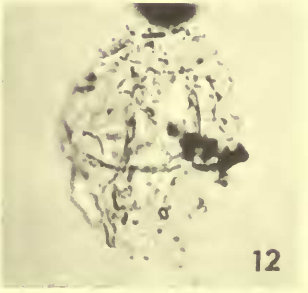
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PLATE 4

Hystrichosphaeridium deanei Davey & Williams

FIG. 1. Lower Chalk, Compton Bay. Complete specimen (137 feet above base of Chalk). Slide CB 19/2. × 500.

Hystrichosphaeridium difficile Manum & Cookson

Upper Colorado, Saskatchewan.

FIG. 2. Complete specimen, archaeopyle partially detached. V.51983 (depth, 805 feet). × 500.

FIG. 6. Detached operculum bearing 4 processes. Slide Sas 805/3 (depth, 805 feet). × 500.

FIG. 7. Detached operculum, lateral view. Slide Sas 805/3 (depth, 805 feet). × 500.
× 500.

Cassiculosphaeridia reticulata sp. nov.

FIG. 3. Holotype; view of archaeopyle. V. 51981 (4). × 500.

Microdinium veligerum (Deflandre).

FIG. 4. Lower Chalk, Fetcham Mill Borehole (depth, 750 feet). Dorsal surface. Slide PF. 3988. × 640.

Microdinium cf. ***ornatum*** Cookson & Eisenack

FIG. 5. Lower Chalk, Escalles Borehole (depth, 189 metres). Dorsal surface. Slide E 189/4. × 640.

Hystrichosphaeridium radiculatum Davey & Williams

FIG. 8. Lower Chalk, Escalles Borehole (depth, 159 metres). Lateral view showing archaeopyle. V. 51982. × 500.

Hystrichosphaeridium mantelli Davey & Williams.

FIG. 9. Lower Chalk, Escalles Borehole (depth, 153 metres). Lateral view to show archaeopyle. Slide E 153/3. × 500.

Polysphaeridium laminaspinosum Davey & Williams

Lower Chalk, Fetcham Mill Borehole.

FIG. 10. Apical view showing archaeopyle. Slide PF. 3035 (depth, 840 feet). × 500.

FIG. 11. Antapical view. Slide PF. 3035 (depth, 840 feet). × 500.


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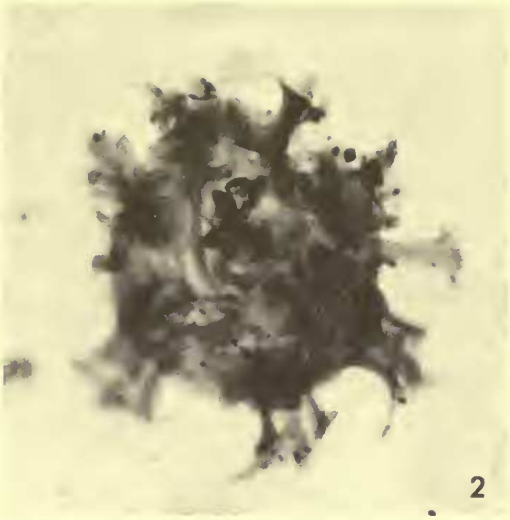
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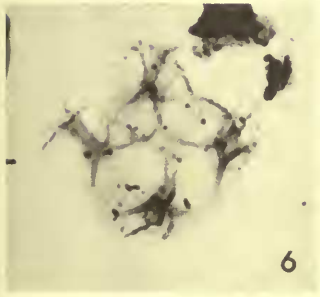
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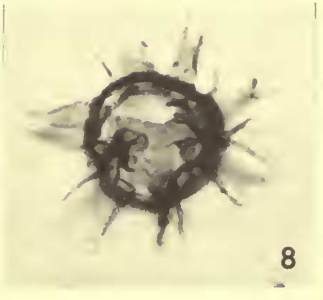
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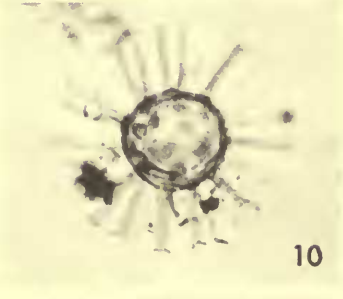
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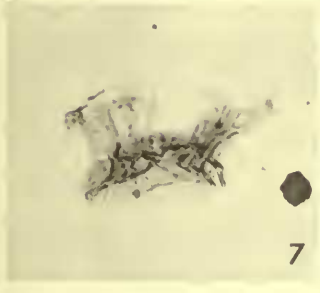
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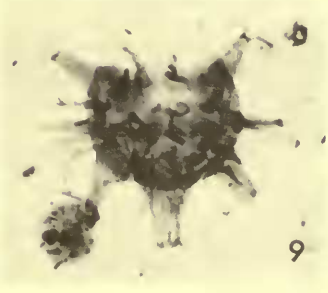
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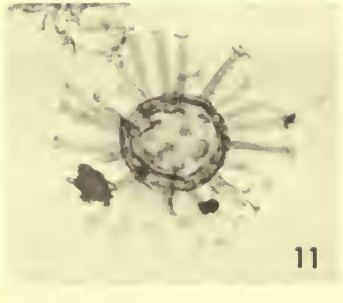
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PLATE 5

Oligosphaeridium anthophorum (Cookson & Eisenack)

Lower Colorado, Saskatchewan.

FIG. 1. Enlargement to show process extremities. Slide Sas 1023/3 (depth, 1023 feet). × 975.

FIG. 2. Detached operculum. Slide Sas 1023/1 (depth, 1023 feet). × 500.

FIG. 3. V. 51980 (boring depth, 1023 feet). × 500.

Oligosphaeridium prolixispinosum Davey & Williams

FIG. 4. Lower Chalk, Compton Bay (116 feet above the base of the Chalk). Specimen showing " bald " cingular region. Slide CB 17/C. × 500.

Hystrichosphaeridium tubiferum (Ehrenberg)

Lower Chalk, Fetcham Mill Borehole.

FIG. 5. Detached operculum. Slide FM 690/12 (depth, 690 feet). × 500.

FIG. 8. Slide PF. 3987 (depth, 730 feet). × 500.

Oligosphaeridium complex (White)

FIG. 6. Lower Chalk, Escalles Borehole (depth, 159 metres). Detached operculum composed of 4 plates. V. 51982. × 500.

FIG. 7. Lower Chalk, Fetcham Mill Borehole (depth, 750 feet). Specimen illustrating the 6 precingular processes. Slide FM 750/13. × 500.

Hystrichosphaeridium bowerbanki Davey & Williams

FIG. 9. Lower Chalk, Compton Bay (116 feet above the base of the Chalk). Lateral view, archaeopyle to the north. Slide CB 17/C. × 500.


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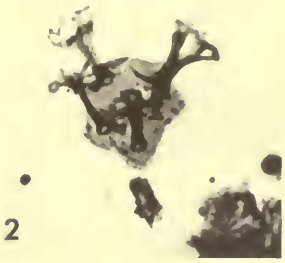
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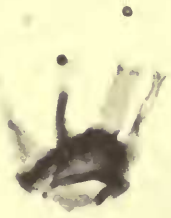
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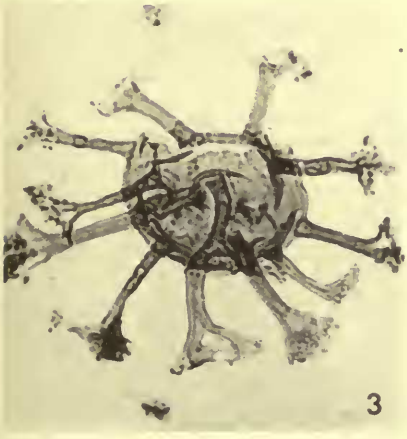
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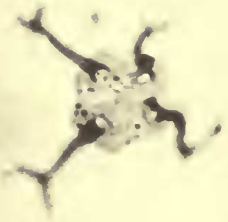
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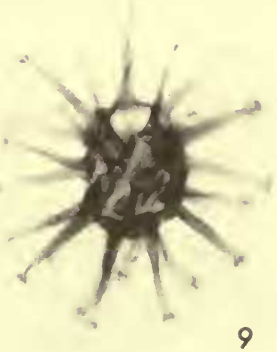
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PLATE 6

Oligosphaeridium reniforme (Tasch)

FIG. 1. Lower Colorado, Saskatchewan (depth, 1023 feet). Slide Sas 1023/1. × 500.

Tanyosphaeridium variecalamum Davey & Williams

FIG 2 Holotype. Slide PF 3035 (2) × 500

FIG 5 Lower Chalk, Compton Bay (28 feet above base of Chalk). Precingular, cingular and postcingular processes aligned into three series. Slide CB 5/C × 500

Litosphaeridium siphoniphorum (Cookson & Eisenack)

Lower Chalk, Fetcham Mill Borehole.

FIG. 3. Lateral view showing precingular and postcingular processes, and antapical process. Slide PF. 3987 (depth, 730 feet). × 500.

FIG. 4. Detached operculum. Slide FM 690/14 (depth, 690 feet). × 975.

Callaiosphaeridium asymmetricum (Deflandre & Courteville).

FIG. 6. Upper Greensand, Fetcham Mill Borehole (depth, 886 feet). Lateral view illustrating epitractal archaeopyle. Slide FM 886/2. × 500.

Cleistosphaeridium polypes (Cookson & Eisenack)

FIG. 7. Upper Woodbine Formation. Enlargement to show process extremities. Slide T5/3. × 975.

FIG. 8. Lower Chalk, Compton Bay (151 feet above base of Chalk). Specimen possessing apical archaeopyle. Slide CB 21/C. × 500.

Cleistosphaeridium polypes var. ***clavulum*** nov.

FIG. 9. Type. Slide PF. 3995 (1) × 500.

FIG. 10. Lower Chalk, Fetcham Mill Borehole (depth, 840 feet). Enlargement to show process extremities. Slide PF. 3035. × 975.

?Cleistosphaeridium aciculare sp. nov.

FIG. 11. Upper Colorado, Saskatchewan (depth, 835 feet). Specimen with numerous fine processes. V. 51988. × 500 (phase contrast).

FIG. 12. Holotype. V. 51979 (3). × 500.


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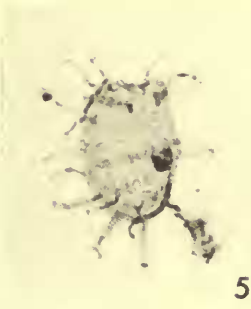
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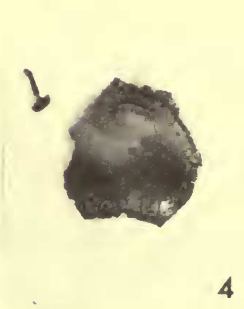
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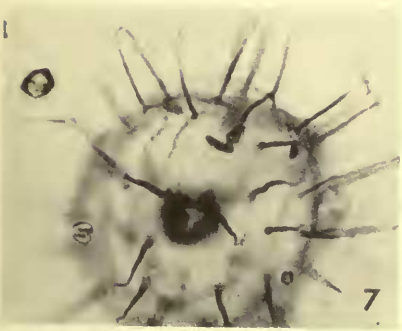
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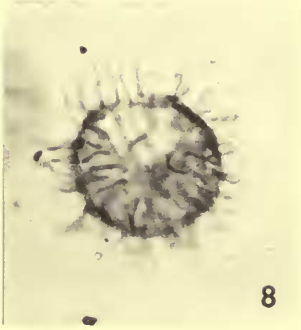
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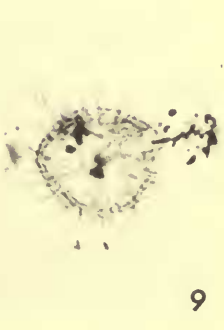
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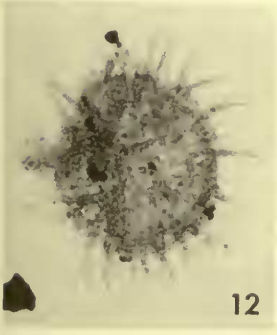
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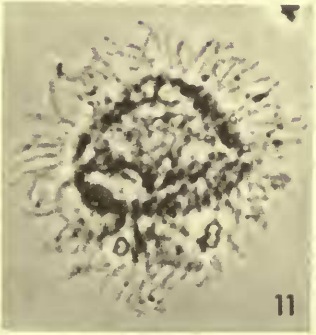
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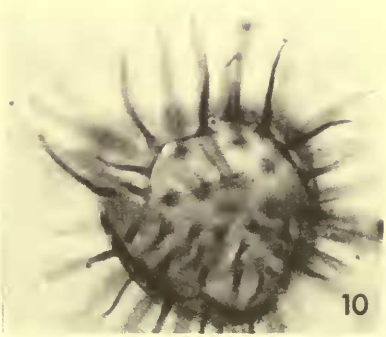
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PLATE 7

Exochosphaeridium striolatum var. ***truncatum*** nov.

FIG. 1. Lower Chalk, Fetcham Mill Borehole (depth, 750 feet). Apical view showing two partially detached precingular plates to the north. Slide PF. 3988. × 500.

FIG. 2. Type; precingular archaeopyle clearly shown to be formed by the removal of two plates. V. 51982 (1). × 500.

FIG. 3. Lower Chalk, Escalles Borehole (depth, 165 metres). Detached operculum composed of two precingular plates. V. 51981. × 500.

?Cleistospaeridium flexuosum Davey *et al.*

FIG. 4. Lower Chalk, Fetcham Mill Borehole (depth, 690 feet). Slide PF. 3030. × 500 (phase contrast).

Exochosphaeridium phragmites Davey *et al.*

FIG. 5. Lower Chalk, Escalles Borehole (depth, 165 metres). Apical process with precingular archaeopyle to the north-west. V. 51981. × 500.

Cleistosphaeridium huguonioti var. ***pertusum*** nov.

FIG. 6. Lower Chalk, Fetcham Mill Borehole (depth, 690 feet). Enlargement showing vacuolated processes with small distal bifurcations. Slide FM 690/14. × 975.

FIG. 7. Type. Slide PF. 3040 (2). × 500.

FIG. 9. Lower Chalk, Escalles Borehole (depth, 159 metres). Specimen possessing apical archaeopyle. Slide E 159/4. × 500.

Cleistosphaeridium heteracanthum (Deflandre & Cookson)

FIG. 8. Lower Chalk, Compton Bay (137 feet above base of Chalk). Slide CB 19/2. × 500.

Cleistosphaeridium huguonioti (Valensi)

FIG. 10. Lower Chalk, Fetcham Mill Borehole (depth, 730 feet). Detached operculum. Slide FM 730/19. × 975.

?Cleistosphaeridium parvum sp. nov.

FIG. 11. Holotype. V. 51981 (3). × 975.

FIG. 12. Lower Chalk, Escalles Borehole (depth, 159 metres). Cingular region devoid of processes clearly visible. Slide E 159/1. × 975.


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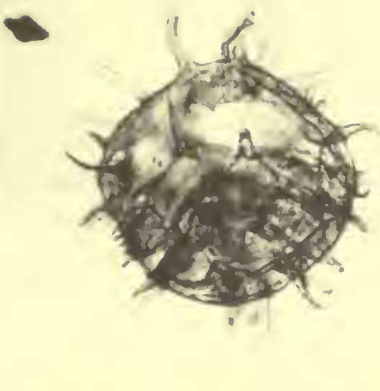
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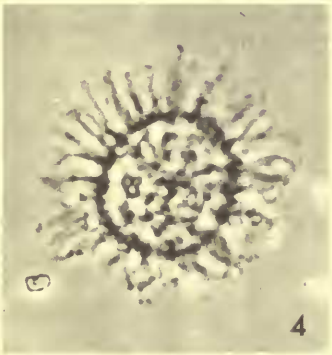
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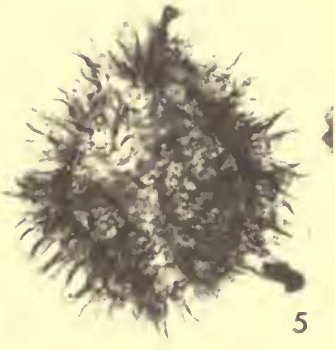
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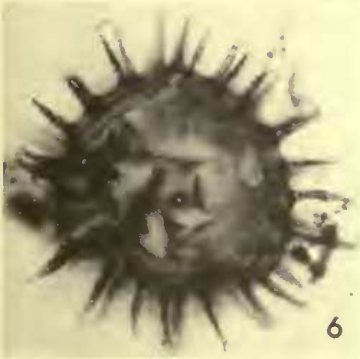
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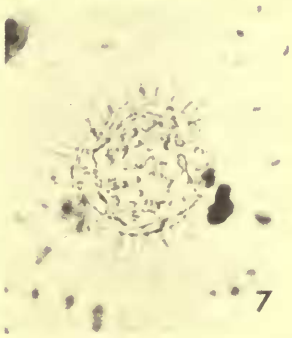
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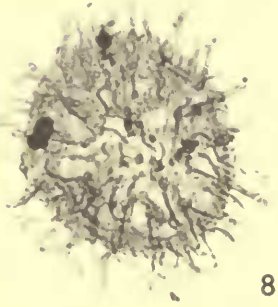
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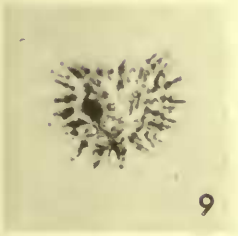
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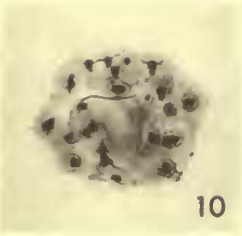
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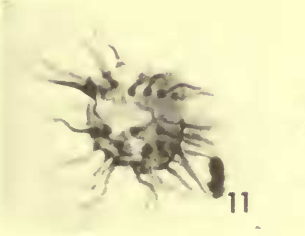
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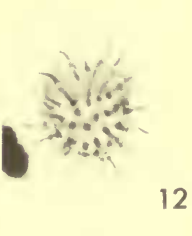
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PLATE 8

Cleistosphaeridium armatum (Deflandre)

FIG. 1. Lower Chalk, Escalles Borehole (depth, 189 metres). View of apical archaeopyle. Slide E 189/4. × 975.

FIG. 2. Lower Chalk, Compton Bay (116 feet above base of Chalk). Enlargement to show process extremities. Slide CB 17/C. × 975.

FIG. 12. Lower Chalk, Compton Bay (116 feet above base of Chalk). Slide CB 17/C. × 500.

Cyclonephelium eisenacki sp. nov.

FIG. 3. Lower Colorado, Saskatchewan (depth, 1,023 feet). Specimen with archaeopyle developed. V.51980. × 500.

FIG. 4. Holotype. V. 51980 (2). × 500.

Prolixosphaeridium conulum sp. nov.

FIG. 5. Holotype; complete specimen. V. 51981 (5). × 500.

FIG. 6. Lower Chalk, Compton Bay (59 feet above base of Chalk). Apical archaeopyle to the north. Slide CB 9/2. × 500.

Cleistosphaeridium multifurcatum (Deflandre)

FIG. 7. Lower Chalk, Escalles Borehole (depth, 207 metres). View of apical archaeopyle. Slide E 207/5. × 500.

FIG. 10. Lower Chalk, Compton Bay (15 feet above base of Chalk). Complete specimen. V. 51986. × 500.

Coronifera oceanica Cookson & Eisenack

FIG. 8. Lower Chalk, Fetcham Mill Borehole (depth, 730 feet). Specimen possessing an apical archaeopyle and an antapical process. Slide FM 730/13. × 500.

FIG. 11. Lower Chalk, Escalles Borehole (depth, 189 metres). Complete specimen. Slide E 189/4. × 500.

Surculosphaeridium longifurcatum (Firtion)

FIG. 9. Lower Chalk, Fetcham Mill Borehole (depth, 730 feet). Lateral view to show apical archaeopyle, deeply furcate precingular processes and completely subdivided cingular processes. Slide PF. 3987. × 500.


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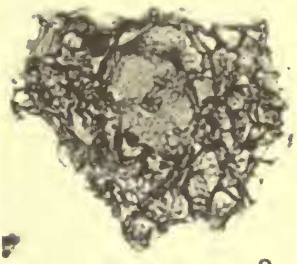
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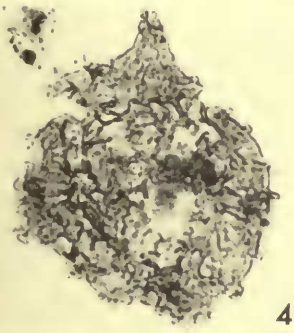
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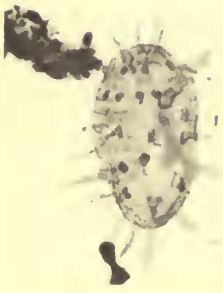
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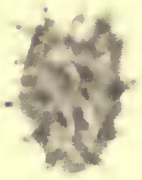
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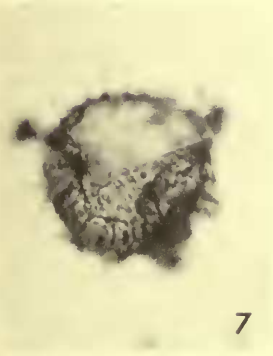
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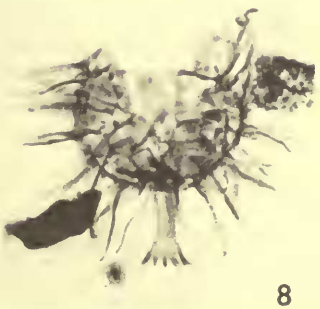
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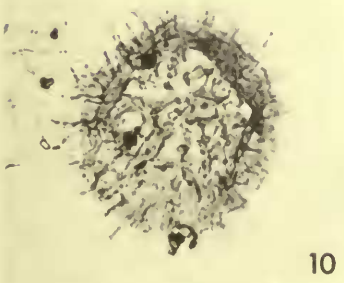
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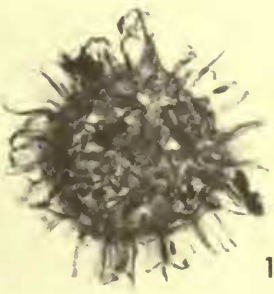
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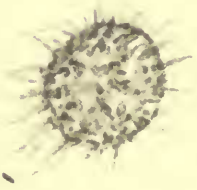
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PLATE 9

Cyclonephelium paucispinum sp. nov.

Fig. 1. Holotype. V. 51981 (2). × 500.

Fig. 2. Lower Chalk, Compton Bay (15 feet above base of Chalk). Complete specimen with operculum partially detached. V. 51986. × 500.

Cyclonephelium vannophorum sp. nov.

Fig. 3. Enlargement of holotype to show apical archaeopyle, and the shape of the processes. V. 51986 (1). × 975.

Cyclonephelium eisenacki sp. nov.

Fig. 4. Lower Colorado, Saskatchewan (depth, 1,023 feet). Complete specimen. Slide Sas 1023/3. × 500.

Hystrichokolpoma ferox (Deflandre)

Lower Chalk, Fetcham Mill Borehole (depth, 840 feet). Slide FM 840/11.

Fig. 5. Lateral view (bottom of specimen by transparency) showing precingular, cingular and postcingular processes; large antapical process to the south and fine sulcal processes to the west. × 500.

Fig. 6. Medial section. × 500.

Fig. 7. Lateral view (top of specimen) showing precingular, cingular and postcingular processes. × 500.


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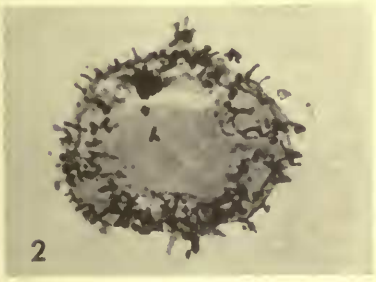
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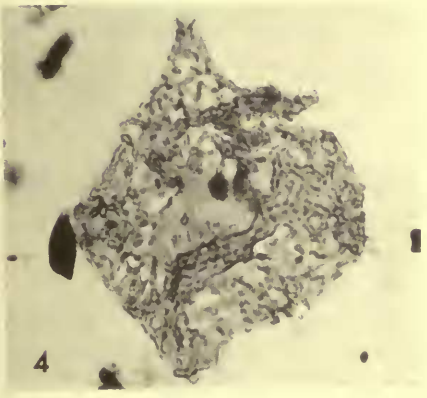
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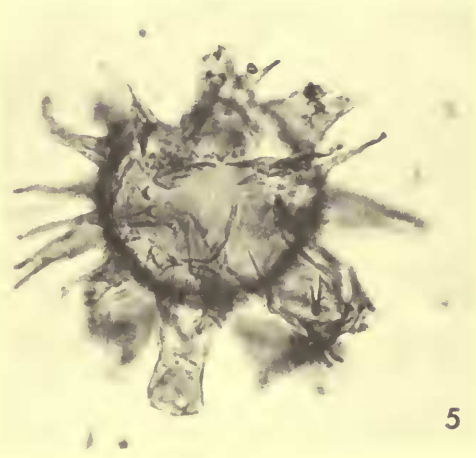
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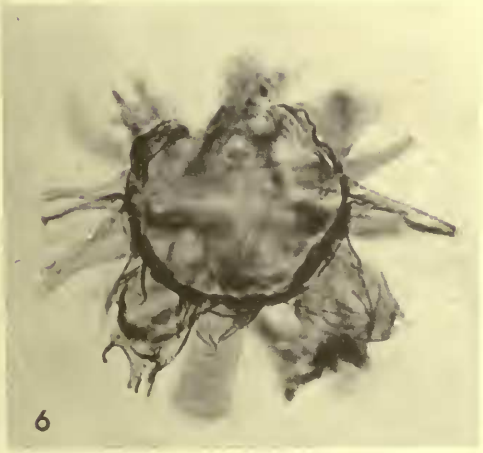
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PLATE 10

Hystrichosphaera ramosa var. ***ramosa*** (Ehr.)

Lower Chalk, Fetcham Mill Borehole (depth, 750 feet).

FIG. 1. Ventral surface. Slide PF. 3988. × 500.
FIG. 2. Dorsal surface with precingular archaeopyle. Slide PF. 3988. × 500.
FIG. 5. Detached operculum (boring depth, 770 feet). Slide FM 770/15. × 500.

Hystrichosphaera ramosa var. ***multibrevis*** Davey & Williams

Lower Chalk, Fetcham Mill Borehole.

FIG. 3. Slide PF. 3988 (depth, 750 feet). × 500.
FIG. 4. Slide PF. 3988 (depth, 750 feet). × 500.

Hystrichodinium voigti (Alberti)

Lower Chalk, Escalles Borehole.

FIG. 6. Archaeopyle to the north-east. V. 51982 (depth, 159 metres).
FIG. 10. Detached operculum bearing 4 processes. Slide E 165/1 (depth, 165 metres). × 500.

Achomosphaera ramulifera (Deflandre)

FIG. 7. Lower Chalk, Escalles Borehole (depth, 159 metres). Specimen showing precingular archaeophyle and apical process. V. 51982. × 500.

Hystrichodinium dasys sp. nov.

FIG. 8. Holotype illustrating cingulum. V. 51982 (3). × 500.
FIG. 9. Middle Chalk, Fetcham Mill Borehole (depth, 520 feet). Specimen with unusually stout processes proximally. Slide FM 520/7. × 500.

Adnatosphaeridium chonetum (Cookson & Eisenack)

FIG. 11. Lower Chalk, Escalles Borehole (depth, 165 metres). Complete specimen, V. 51981. × 500.
FIG. 12. Lower Chalk, Fetcham Mill Borehole (depth, 730 feet). Apical archaeopyle present. Slide PF. 3987. × 500.


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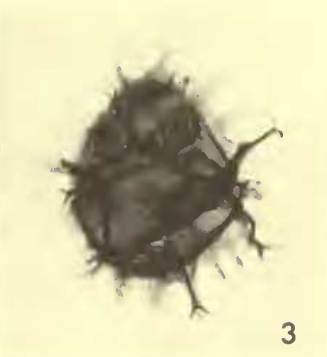
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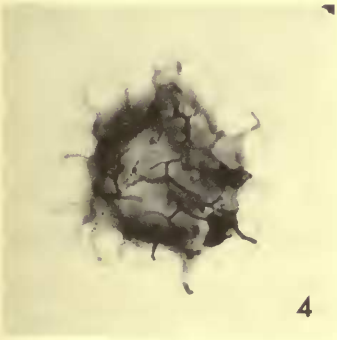
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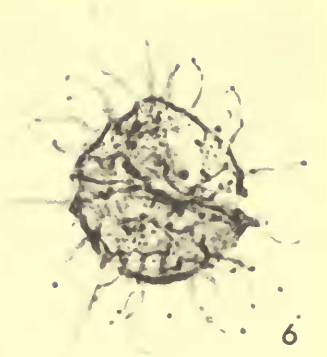
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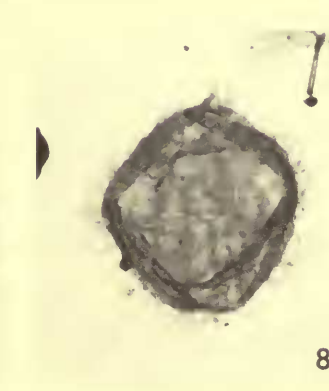
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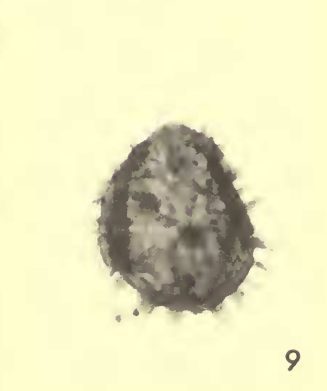
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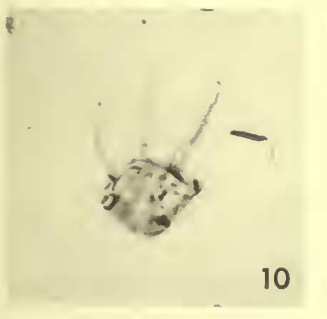
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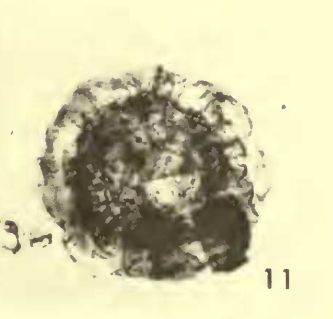
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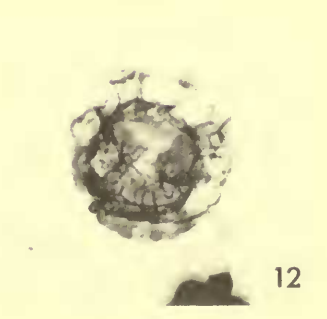
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PLATE 11

Trichodinium castaneum (Deflandre).

Lower Chalk, Escalles Borehole.

FIG. 1. Lateral view showing precingular archaeopyle and cingulum, V. 51989 (depth, 195 metres). × 500.

FIG. 2. Dorsal view showing small apical horn. Slide E 159/2 (depth, 159 metres). × 500.

FIG. 3. Complete specimen possessing a cingulum and possibly a sulcus, Slide E 189/4 (depth, 189 metres). × 500.

Exochosphaeridium pseudohystrichodinium (Deflandre)

Lower Chalk, Escalles Borehole.

FIG. 4. Complete specimen with operculum partially detached, V. 51982 (depth, 159 metres). × 500.

FIG. 5. Complete specimen illustrating pitted surface, V. 51981 (depth, 165 metres). × 500.

Cyclonephelium distinctum Deflandre & Cookson

FIG. 6. Lower Chalk, Escalles Borehole (depth, 159 metres). Specimen with unusually long processes, V. 51982. × 500.

FIG. 7. Lower Chalk, Escalles Borehole (depth, 159 metres). Complete specimen; archaeopyle in the act of developing. V. 51989. × 500.

FIG. 8. Lower Chalk, Compton Bay (15 feet above base of Chalk). Typical specimen with archaeopyle developed. V. 51986. × 500.

FIG. 10. Lower Chalk, Escalles Borehole (depth, 165 metres). Detached operculum. V. 51981. × 500.

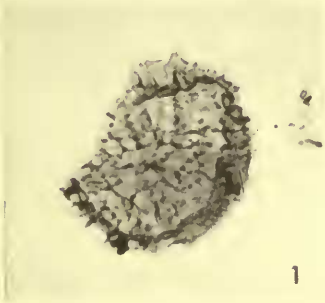
Cyclonephelium membraniphorum Cookson & Eisenack

FIG. 9. Lower Chalk, Escalles Borehole (depth, 153 metres). Apical archaeopyle well illustrated. Slide E 153/3. × 500.

Cyclonephelium vannophorum sp. nov.

FIG. 11. Holotype with operculum partially detached. V. 51986 (1). × 500.

FIG. 12. Lower Chalk, Compton Bay (15 feet above base of Chalk). Specimen with apical archaeopyle developed. V. 51986. × 500.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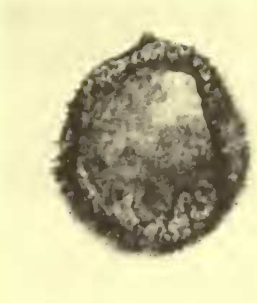
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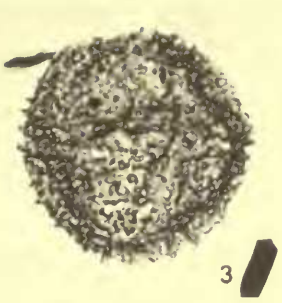
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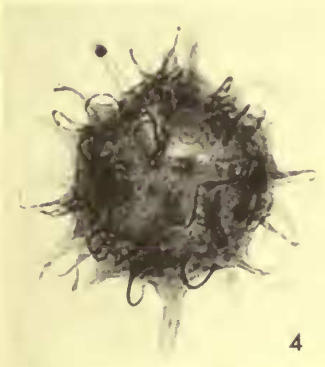
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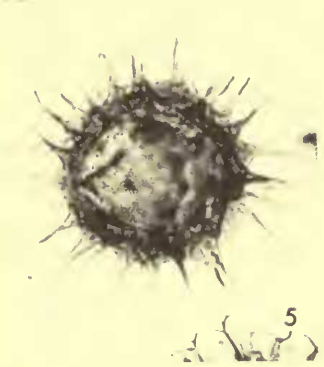
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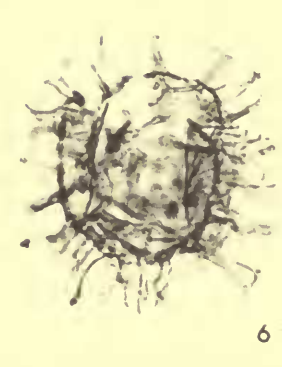
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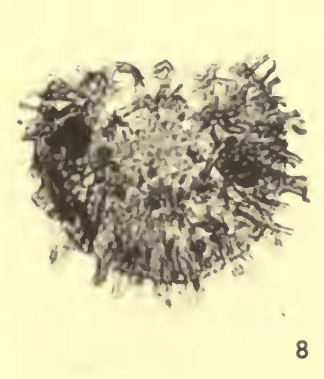
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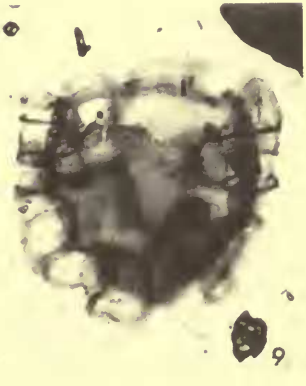
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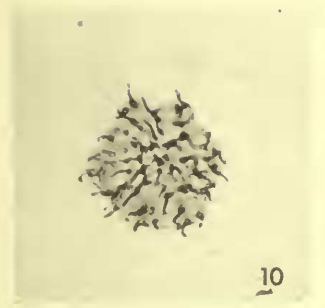
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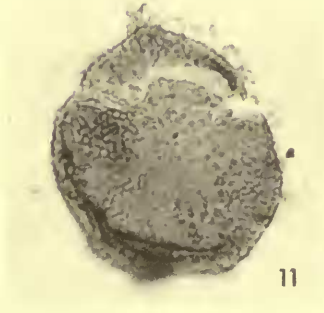
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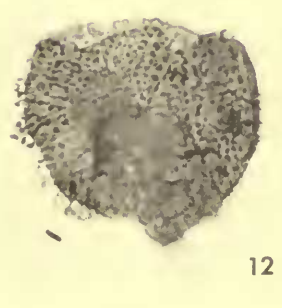
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